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Growth and Yield of Sitka Spruce and Western Hemlock at Cascade Head Experimental Forest, Oregon

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Cascade
Head

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Abstract

Summary

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A study established in 83-year-old, even-aged stands of Sitka spruce (*Picea sitchensis* (Bong.) Carr.) and western hemlock (*Tsuga heterophylla* (Raf.) Sarg.) at Cascade Head Experimental Forest in the Siuslaw National Forest on the Oregon coast traces their development for 33 years. Statistical data collected from 12 permanent sample plots during four periods of growth illustrate the tremendous productive capacity of the Sitka spruce–western hemlock type.

Keywords: Increment (volume), stand volume, increment (basal area), increment (height), even-aged stands, Sitka spruce, *Picea sitchensis,* western hemlock, *Tsuga heterophylla.*

Sitka spruce (*Picea sitchensis* (Bong.) Carr.) and western hemlock (*Tsuga heterophylla* (Raf.) Sarg.) are the principal components of the Pacific Northwest coastal fog belt type (Meyer 1937) or the *Picea sitchensis* zone (Franklin and Dyrness 1973) found along the Oregon and Washington coasts. The tremendous potential for rapid growth and high yield of the Sitka spruce–western hemlock type ranks it among the most productive coniferous types in the world.

This report summarizes 33 years of data on growth and yield of mixed stands of Sitka spruce and western hemlock at Cascade Head Experimental Forest in the Siuslaw National Forest on the Oregon coast. Data were collected from 16 permanent sample plots established in the spring of 1935; 12 of the plots were in thrifty, well-stocked, 83-year-old, even-aged stands of Sitka spruce and western hemlock. The 12 plots were periodically remeasured to obtain detailed information about the silvical and growth characteristics of the type during four periods spanning 33 years; the study was concluded in 1968.

This report describes the study, summarizes data obtained from the permanent sample plots, and discusses results. Our primary purpose in presenting these data is to further define the extraordinary productivity of the Sitka-spruce–western hemlock coastal forest. This information on growth and yield focuses on cause-and-effect relationships rather than on indepth statistical analyses of the data.

Contents

Introduction

The Study Area

Sitka spruce (*Picea sitchensis* (Bong.) Carr.) and western hemlock (*Tsuga heterophylla* (Raf.) Sarg.) permanent growth plots are located in the Cascade Head Experimental Forest, Siuslaw National Forest, near Otis on the Oregon coast (fig. 1). The 130-year-old forest supports a well-stocked stand of Sitka spruce and western hemlock, believed to have become established after the 350,000-acre (141 640-ha) Nestucca fire in 1845. The local climate is typical of the coastal fog belt with heavy precipitation, high humidity, frequent fog, and a minimum of temperature extremes (Franklin and Dyrness 1973). The Pacific Ocean influences the mild climate, providing a long growing season and favorable moisture conditions, even in the summer when frequent fog and clouds compensate for otherwise drier conditions (table 1).
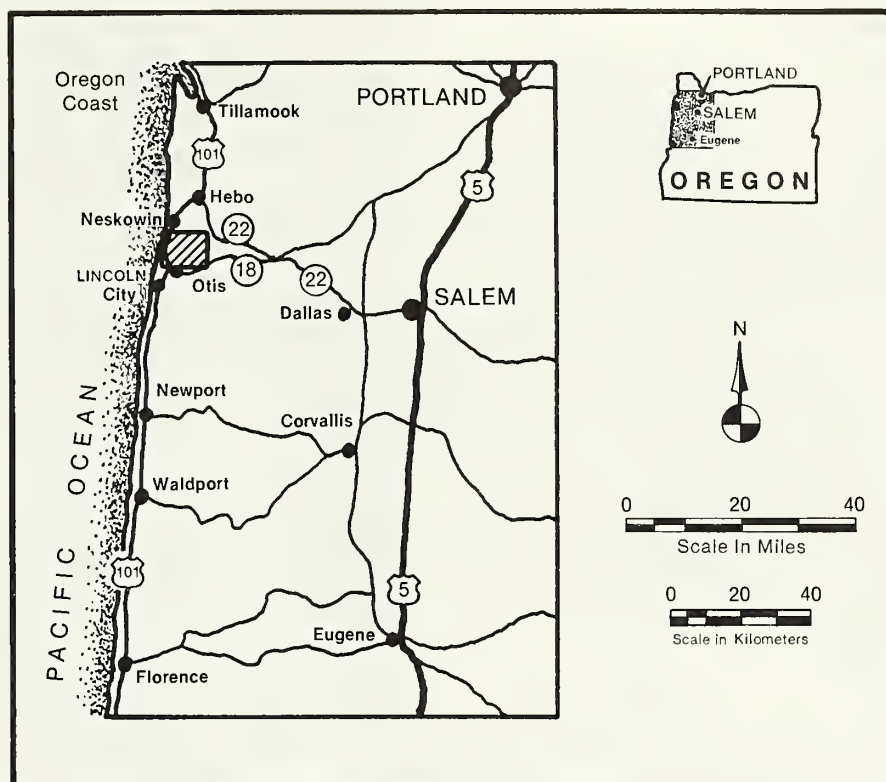

Figure 1.—Location of Cascade Head Experimental Forest.

Table 1—Comparison of climatic data for Cascade Head Experimental Forest (Otis, Oregon) with representative stations throughout the Pacific Northwest

| Station | Elevation | Average air temperature | | | | | Precipitation | |
		Annual	January	January minimum	July	July maximum	Average annual	June–August
	Feet (Meters)	°F (°C)	°F (°C)	°F (°C)	°F (°C)	°F (°C)	Inches (Centimeters)	Inches (Centimeters)
Otis, Oregon	161 (49.1)	50.5 (10.3)	41.5 (5.3)	36.0 (2.2)	59.5 (15.3)	69.6 (20.3)	98.3 (250)	6.4 (16)
Corvallis, Oregon	203 (61.9)	52.3 (11.3)	39.2 (4.0)	33.1 (.6)	66.0 (18.9)	80.8 (27.1)	39.5 (100)	1.9 (5)
Medford, Oregon	1,312 (399.9)	54.0 (12.2)	37.4 (3.0)	29.8 (-1.2)	72.1 (22.3)	89.2 (31.8)	19.6 (50)	1.4 (4)
Portland, Oregon	29 (8.8)	54.7 (12.6)	40.3 (4.6)	34.5 (1.4)	68.5 (20.3)	78.4 (25.8)	42.4 (108)	2.8 (7)
Seattle, Washington	111 (33.8)	52.9 (11.6)	40.1 (4.5)	34.0 (1.1)	65.7 (18.7)	75.4 (24.1)	35.0 (89)	3.1 (8)

Source: Franklin and Dyrness (1973).

Methods

In the spring of 1935, 16 permanent sample plots were established in even-aged stands of Sitka spruce and western hemlock, having an average age of 83 years.[1] Twelve 1-acre (0.405-ha) plots (fig. 2) varied in composition from nearly pure spruce to pure hemlock. The remaining plots were established in younger stands containing substantial amounts of red alder (*Alnus rubra* Bong.) and Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco). For each plot, boundaries were established, boundary trees

[1] Meyer, W. H. 1935. First report on sixteen permanent sample plots located on the Cascade Head Experimental Forest. 37 p. On file at Forestry Sciences Laboratory (Jerry F. Franklin), Corvallis, Oregon.

blazed, and corner posts set and numbered. Plot trees were tagged with aluminum tags 4.5 feet (1.37 m) above seedling origin.[2] Heights of 10 to 40 trees per acre (24.7 to 98.8/ha) were measured to the nearest foot (30.5 cm). Diameters at breast height were measured to the nearest 0.1 inch (0.254 cm). Age counts were made on increment cores from 10 to 15 trees per plot. The plots were remeasured in 1940, 1945, 1955, and 1968 for the growth periods of 1935-40, 1941-45, 1946-55, and 1956-68. Of the 12 original spruce and hemlock plots, only 9 exist today; plot 2 was lost to roadbuilding; plot 6 to the 1962 Columbus Day windstorm; and plot 9 to logging activities. Initially, volume-diameter-height relationships were developed from tarif access equations for trees with height measurements (total height was measured on only a portion of the trees on a plot). Procedures for processing tarif access numbers by computer were adopted by use of British Columbia volume equation coefficients for immature

[2] At 4½ feet (1.37 m) above seedling origin, breast height was as much as 10 feet (3.05 m) above ground level for trees that began growth on rotted logs or stumps.

coastal western hemlock, Sitka spruce, and Douglas-fir (Brackett 1973). Tarif access numbers for individual sample trees were calculated and tabulated by species, plot, and measurement year. Because of the high variation in the number of trees and the large range of diameter classes on individual plots, tarif access numbers were averaged and adjusted for each measurement year by species to determine an overall "average" tarif number (tables 2 and 3). This procedure provided a more adequate representation of tree diameters over the range of diameter classes; it also removed inconsistencies caused by the variation in the number of sample trees selected per plot and in height measurements between measurement years. The resulting adjusted access numbers were used in conjunction with the collected data on tree diameters to obtain individual estimates of volume for each tree. These estimates of volume, as well as other individual tree measurements, were tabulated and summarized by species, plot, and measurement year; they represent the basic statistical data presented in this report.
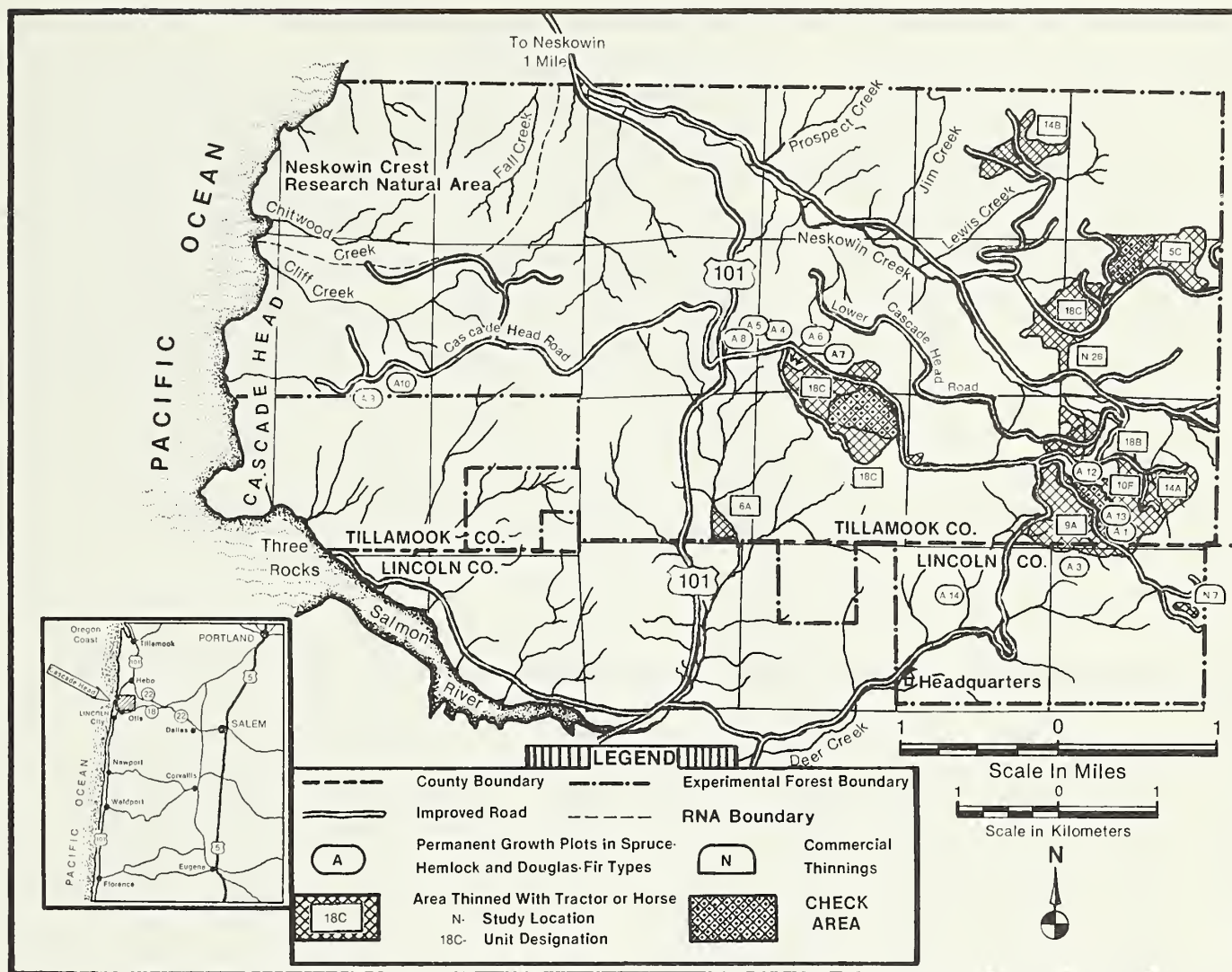
Figure 2.—Location of the 12 plots periodi-
cally remeasured, Cascade Head Experi-
mental Forest.

Table 2—Average tarif number for Sitka spruce by 1-acre (0.405-ha) plot and measurement year[1]

Plot	1935, age 83		1940, age 89		1945, age 94		1955, age 104		1968, age 116	
	Average tarif number	Number of height trees	Average tarif number	Number of height trees	Average tarif number	Number of height trees	Average tarif number	Number of height trees	Average tarif number	Number of height trees
1	--	0	45.3	4	--	0	48.9	3	49.9	3
3	53.3	23	55.1	15	55.4	33	57.1	22	59.5	11
4	46.4	20	49.0	33	47.6	28	49.4	30	51.7	24
5	48.7	27	53.0	32	52.8	31	53.9	32	56.6	30
6	44.6	8	46.2	10	47.4	9	51.0	12	--	--
7	46.8	13	49.5	9	53.0	10	50.3	12	53.5	11
8	46.6	1	--	0	--	0	48.5	2	46.0	3
9	40.7	24	41.7	46	--	--	--	--	--	--
10	38.8	22	41.1	22	41.5	22	44.2	25	47.4	26
12	47.7	10	49.1	10	51.2	9	50.5	12	54.0	9
13	48.5	8	50.8	9	51.6	9	53.7	8	56.2	10
Mean[2]	45.9	17.3	49.4	14.9	50.4	15.8	51.0	16.2	53.2	14.1

[1] Tarif number is the total cubic-foot (cubic-meter) volume from the stump to a 4-inch (10.2-cm) top for a tree of 1.0 square foot (0.0929 m^2) basal area at d.b.h. (Chambers and Foltz 1980). Height trees are used for determining average tarif numbers.

[2] Weighted average, weighted by number of height trees per plot.

Table 3—Average tarif number for western hemlock by 1-acre (0.405-ha) plot and measurement year[1]

Plot	1935, age 83		1940, age 89		1945, age 94		1955, age 104		1968, age 116	
	Average tarif number	Number of height trees	Average tarif number	Number of height trees	Average tarif number	Number of height trees	Average tarif number	Number of height trees	Average tarif number	Number of height trees
1	49.6	39	51.3	42	52.1	41	53.2	37	54.9	53
3	53.1	19	54.0	17	53.8	21	54.7	26	59.3	19
4	42.7	19	44.0	10	42.9	11	45.5	16	47.9	15
5	48.8	9	50.6	10	49.8	10	50.2	10	51.3	12
6	50.2	23	50.6	31	48.8	29	53.4	30	--	--
7	49.1	24	49.4	29	52.6	30	50.3	27	52.5	28
8	46.6	31	47.8	44	49.3	41	48.8	34	49.1	32
9	--	0	--	0	--	0	--	--	--	--
10	38.4	17	41.0	21	40.2	23	45.3	26	48.1	20
11	51.7	30	52.5	33	54.2	24	53.7	28	57.1	33
12	53.4	28	53.3	35	54.3	30	55.6	28	57.6	31
Mean[2]	48.7	17.3	49.9	26.8	50.6	25.7	51.2	25.8	53.7	27.0

[1] Tarif number is the total cubic-foot (cubic-meter) volume from the stump to a 4-inch (10.2-cm) top for a tree of 1.0 square foot (0.0929 m^2) basal area at d.b.h. (Chambers and Foltz 1980). Height trees are used for determining average tarif numbers.

[2] Weighted average, weighted by number of height trees per plot.

Results and Discussion

Site Determination

Site index as expressed here is the average height of the dominant and codominant trees of a given stand at 100 years of age. In mixed stands of Sitka spruce and western hemlock, however, several problems associated with determining site index are apparent. First, the height growth characteristics of Sitka spruce and western hemlock differ considerably (Allen 1902, Cary 1922, Taylor 1934). Barnes (1962) noted that Sitka spruce continues to grow much faster than does western hemlock after 100 years. In addition, the height-age relationship varies significantly between geographic regions. Thus, existing site index curves, such as those constructed by Meyer (1937) for Sitka spruce and western hemlock, are no longer a reliable measure of site index (Barnes 1962).

The average total height of dominant and codominant western hemlock by plot and year is given in table 4. A curve of height over diameter was fitted for the dominant and codominant western hemlocks for each measurement year (fig. 3). From these equations and the average diameter of the dominant and codominant trees, the average total height of the dominant and codominant trees was determined. Barnes' (1962) site index curves were interpolated to determine site index for each measurement year; the average site index used in the study was the mean of the estimates for the four periods. There was no distinguishable difference in site index between Barnes' method and ours (fig. 4). The average site index corresponded approximately to site index 144, placing it in site class III.

Table 4—Average total height of dominant and codominant western hemlock trees[1]

Plot[2] number	1935, age 83			1940, age 89			1945, age 94			1955, age 104			1968, age 116		
	Height		Number of trees	Height		Number of trees	Height		Number of trees	Height		Number of trees	Height		Number of trees
	Feet	Meters		Feet	Meters		Feet	Meters		Feet	Meters		Feet	Meters	
1	133	40.5	27	141	43.0	23	142	43.3	22	147	44.8	22	152	46.3	36
2[3]															
3	145	44.2	9	148	45.1	9	142	43.3	4	158	48.2	1	166	50.6	7
4	122	37.2	5	134	40.8	22	132	40.2	11	140	42.7	4	142	43.3	6
5	0	0	0	149	45.4	1	149	45.4	1	0	0	0	124	37.8	1
6	137	41.8	14	140	42.7	13	132	40.2	11	151	46.0	15	4/	4/	4/
7	129	39.3	10	137	41.8	11	143	43.6	15	143	43.6	12	152[5]	46.3	13
8	120	36.6	17	127	38.7	24	129	39.3	18	135	41.1	15	135	41.5	16
9	0	0	0	0	0	0	5/	5/	5/						
10	105	32.0	5	110	33.5	8	113[5]	34.4	7	123	37.5	8	131	39.9	8
12	135	41.1	19	140	42.7	19	146	44.5	18	150	45.7	18	159	48.5	23
13	141	43.0	19	145	44.2	12	144	43.9	17	155	47.2	14	161	49.1	16
Mean[6]	132	40.2		136	41.4		138	42.1		146	44.5		151	46.0	
Site index[7]	146	44.5		144	43.9		142	43.3		144	43.9		142	43.3	

[1] Trees in crown classes 1 and 2.

[2] The 12 plots that were periodically remeasured. Plots 11, 14, 15, and 16 were younger stands with substantial amounts of Douglas-fir and red alder.

[3] Destroyed soon after establishment.

[4] Destroyed in 1962 Columbus Day windstorm.

[5] Accidentally logged.

[6] Weighted average of the total height of all sample trees.

[7] Interpolated from table 2 of Barnes (1962). Average site index = 144 feet (43.9 meters).

Figure 3.—Height-d.b.h. relationship for selected dominant and codominant western hemlock trees by year of measurement. Inconsistencies in measurements apparently caused a discrepancy for 1945.
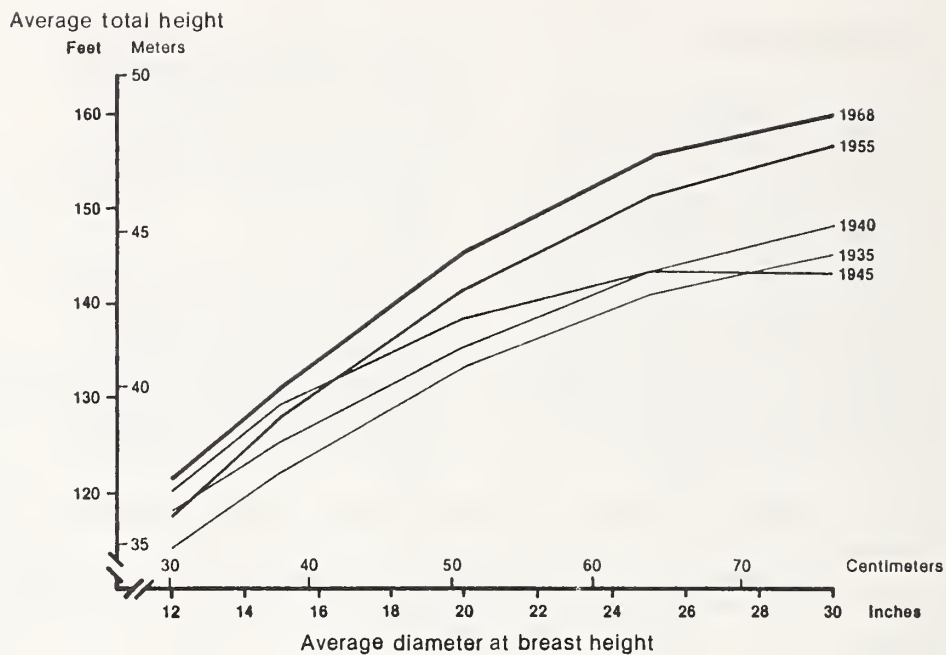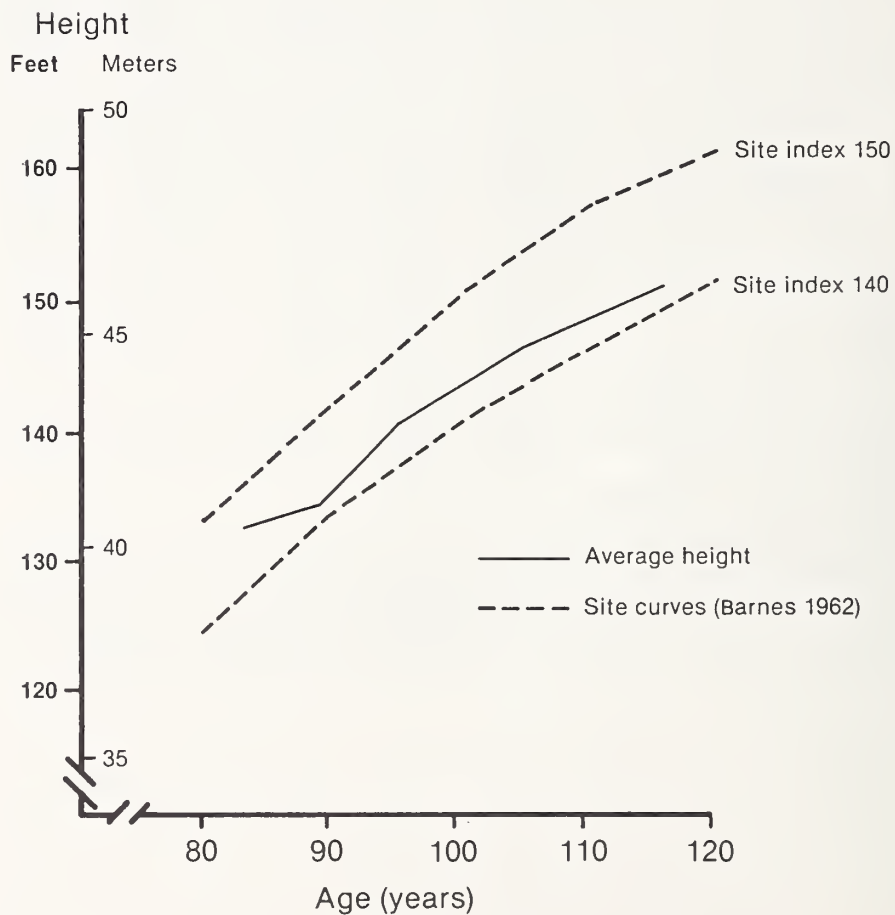
Average total height

Average diameter at breast height

Figure 4.—Average total height of dominant and codominant western hemlock trees. Average site index at age 100 years = 144 feet (43.9 m).

Height

Age (years)

Average Total Height

The analysis of the height growth data presented in tables 5 and 6 in the appendix indicates a significant difference in height between Sitka spruce and western hemlock for the 5 measurement years. The average height differential between Sitka spruce and western hemlock ranged from 11 feet (3.3 m) at age 83 to 22 feet (6.7 m) at age 116. Clearly, Sitka spruce had attained a dominant position in the stand at age 116, reaching an average total height of 161 feet (49.1 m). Figure 5 shows the average total height of western hemlock, Sitka spruce, Douglas-fir, and all species for the 5 measurement years.

Although Douglas-fir is represented as an associated species on several of the growth plots, it is widely scattered throughout the study plots. Since only a few height measurements were taken on Douglas-fir, the height data are perhaps unrealistic. Therefore, no further analysis of the height data was attempted, other than that found in figure 5 and tables 5 and 6 in the appendix. Similarly, other measurement data may not represent the true growth characteristics of Douglas-fir; however, observations indicate that Douglas-fir is not maintaining its dominant position in the study plots at Cascade Head and is, for the most part, undersized and poorly developed.

Basal Area

The shade-tolerant nature of both Sitka spruce and western hemlock has resulted in a dense, even-aged stand of exceptionally high basal area (fig. 6).

Total basal area ranged from 417 ft²/ acre (95.8 m²/ha) at age 83 to 468 ft²/ acre (107.4 m²/ha) at age 116; basal areas of individual plots ranged from 361 to 518 ft²/acre (82.8 to 118.9 m²/ha) at age 116 (appendix tables 7 to 16).
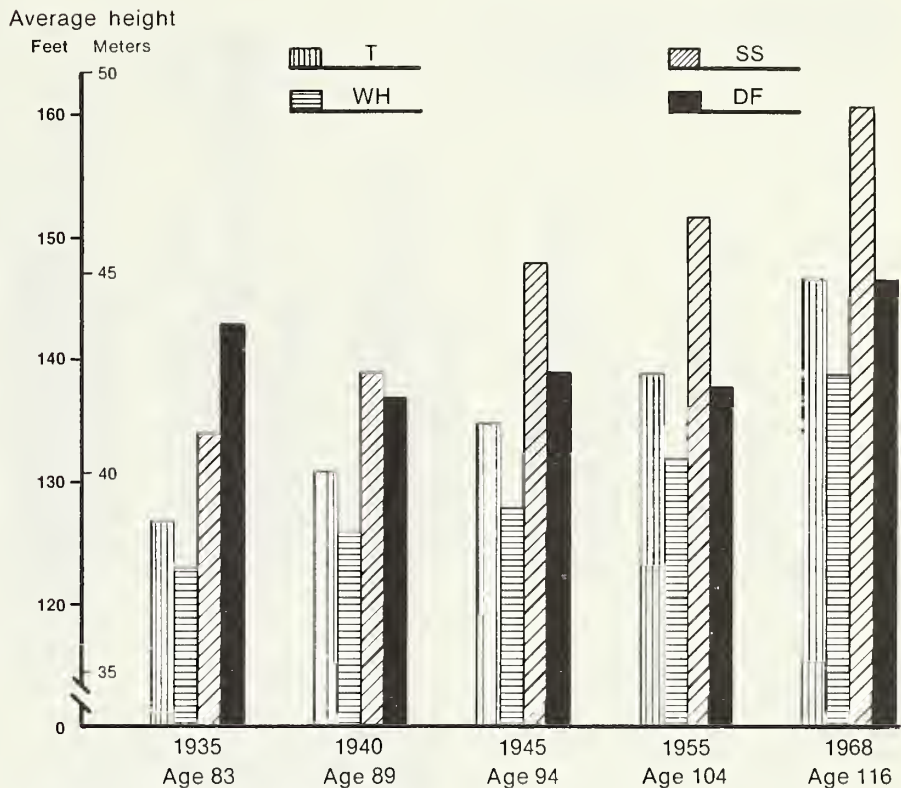

Figure 5.—Average total height of western hemlock (WH), Sitka spruce (SS), Douglas-fir (DF), and all species (T), by year of measurement (all trees 1.6+ inches (4+ cm) in d.b.h.).
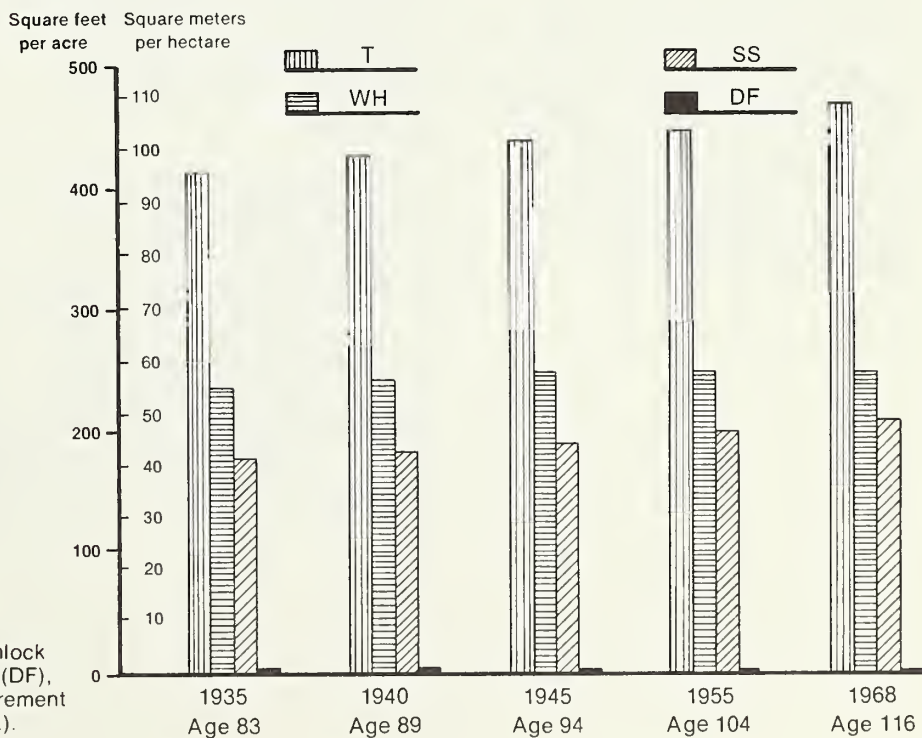

Figure 6.—Basal area of western hemlock (WH), Sitka spruce (SS), Douglas-fir (DF), and all species (T), by year of measurement (all trees 1.6+ inches (4+ cm) in d.b.h.).
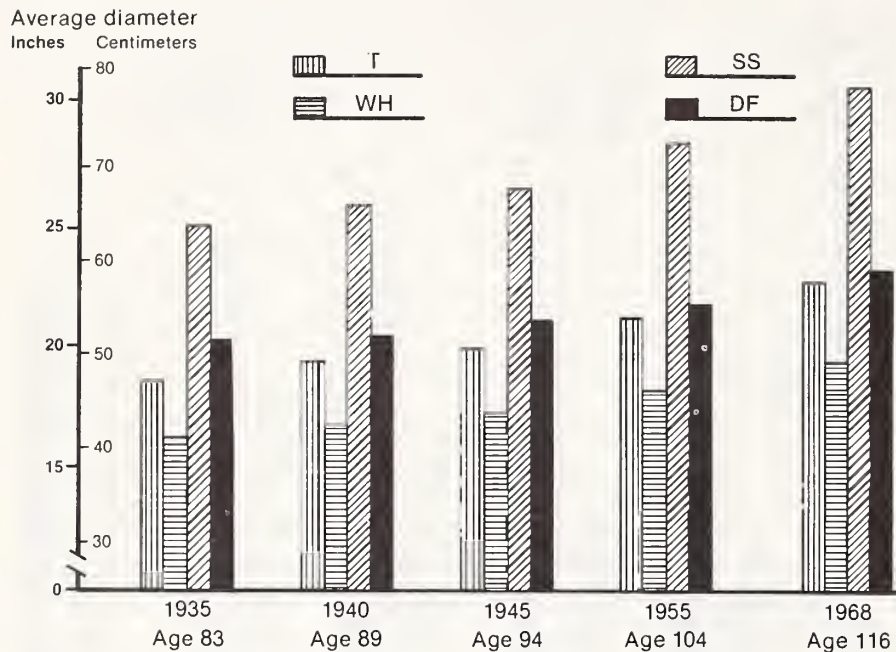
Average diameter
Inches   Centimeters

Figure 7.—Average diameter at breast height of western hemlock (WH), Sitka spruce (SS), Douglas-fir (DF), and all species (T), by year of measurement (all trees 1.6+ inches (4+ cm) in d.b.h.).

Average basal area for western hemlock ranged from 237 ft²/acre (54.4 m²/ha) at age 83 to 252 ft²/acre (57.8 m²/ha) at age 116. Average basal area for Sitka spruce ranged from 176 ft²/acre (40.5 m²/ha) at age 83 to 213 ft²/acre (48.8 m²/ha) at age 116. The relatively stable figure for basal area for western hemlock can be attributed to a gradual decrease in the number of trees per acre (ha) and the increased average diameter of the remaining trees. Average basal area for Douglas-fir remained small and essentially unchanged from 1935 to 1968.

Average Diameter

The diameter growth data (appendix tables 7 to 16) reflect an inherent difference between the growth pattern of Sitka spruce and western hemlock. Sitka spruce typically has a rapid and well-sustained growth habit, whereas western hemlock generally grows at a slower rate than its associates (Allen 1902, Meyer 1937). Figure 7 depicts the average diameter[3] for western hemlock, Sitka spruce, Douglas-fir, and all species for each year of measurement.

The larger average diameter of Sitka spruce is apparent, ranging from 25.1 inches (63.8 cm) in d.b.h. at age 83 to 30.6 inches (78 cm) at age 116; western hemlock ranges from 16.2 inches (41 cm) in d.b.h. at age 83 to 19.4 inches (49.3 cm) at age 116. An analysis of the average diameter indicates that Sitka spruce is significantly larger than western hemlock each year of measurement.

_____
[3] Quadratic mean diameter.

Diameter at breast height for Sitka spruce averages 8.9 inches (22.8 cm) or 55 percent larger than western hemlock at age 83 and averages 11.2 inches (28.4 cm) or 58 percent larger at 116. Although Sitka spruce is significantly larger than western hemlock, measurements of diameter are often confounded by extreme butt swell. Diameter differences at 18 feet (5.5 m) above seedling origin might not be so great.

Number of Trees

Figure 8 shows the average number of western hemlock, Sitka spruce, Douglas-fir, and all species per unit area. The total number of trees per acre (ha) decreased from 218 (539) at age 83 to 166 (410) at age 116. Sitka spruce decreased from 51 trees/acre (126/ha) at age 83 to 43/acre (104/ha) at age 116, whereas western hemlock averaged 165 trees/acre (408/ha) at age 83, decreasing to 123/acre (304/ha) at age 116.

Full stocking on the sample areas was maintained throughout the 1935-68 measurement period. Because western hemlock is relatively shade-tolerant and Sitka spruce maintains a high growth rate, and therefore a dominant position beyond 100 years of age (Barnes 1962), the growing sites were fully occupied. In the mixed even-aged stand of Sitka spruce–western hemlock, the larger number of hemlock trees per unit area can probably be traced to the initial establishment of the stand. Western hemlock is a constant and prolific seeder, but Sitka spruce seeds only occasionally (Meyer 1937). Thus, western hemlock had an advantage over Sitka spruce in numbers of trees per unit area. That numerical advantage is still apparent today.

Figures 9-11 compare the distribution of the number of trees per acre (ha) by 2-inch (5.1-cm) diameter class for western hemlock, Sitka spruce, and all species at ages 83 and 116. Table 17 (appendix) gives stand information for each year of measurement.

Figure 8.—Number of western hemlock (WH), Sitka spruce (SS), Douglas-fir (DF), and all species (T), by year of measurement (trees 1.6+ inches (4+ cm) in d.b.h.).
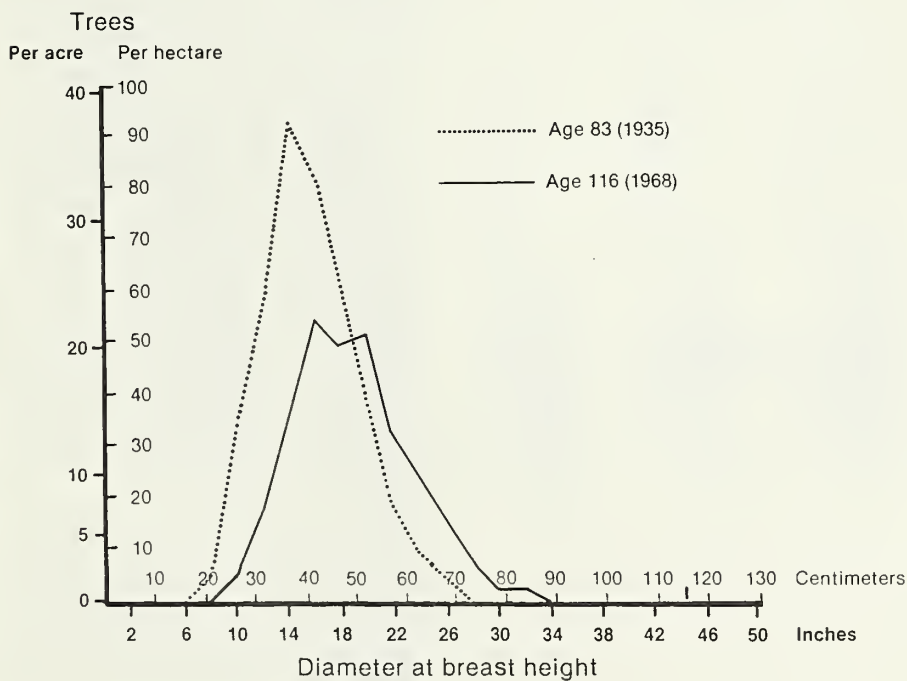
Figure 9.—Distribution of western hemlock trees by 2-inch (5-cm) diameter class (trees 1.6+ inches (4+ cm) in d.b.h.).

Trees

Per acre   Per hectare
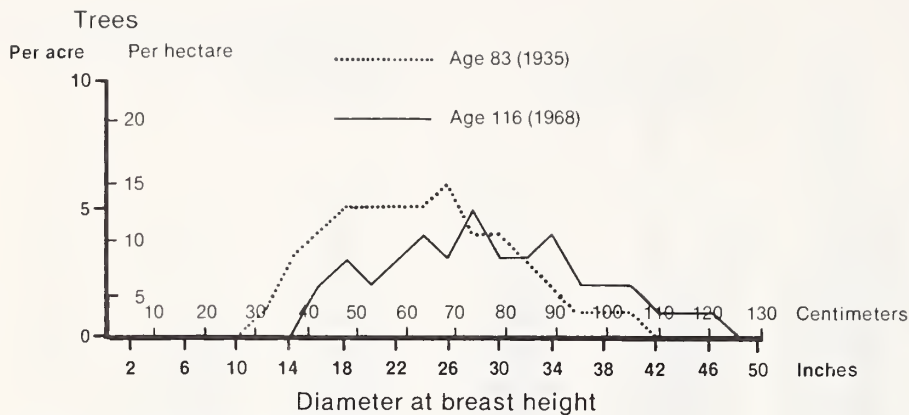
Figure 10.—Distribution of Sitka spruce
trees by 2-inch (5-cm) diameter class (trees
1.6+ inches (4+ cm) in d.b.h.).

Trees

Per acre   Per hectare
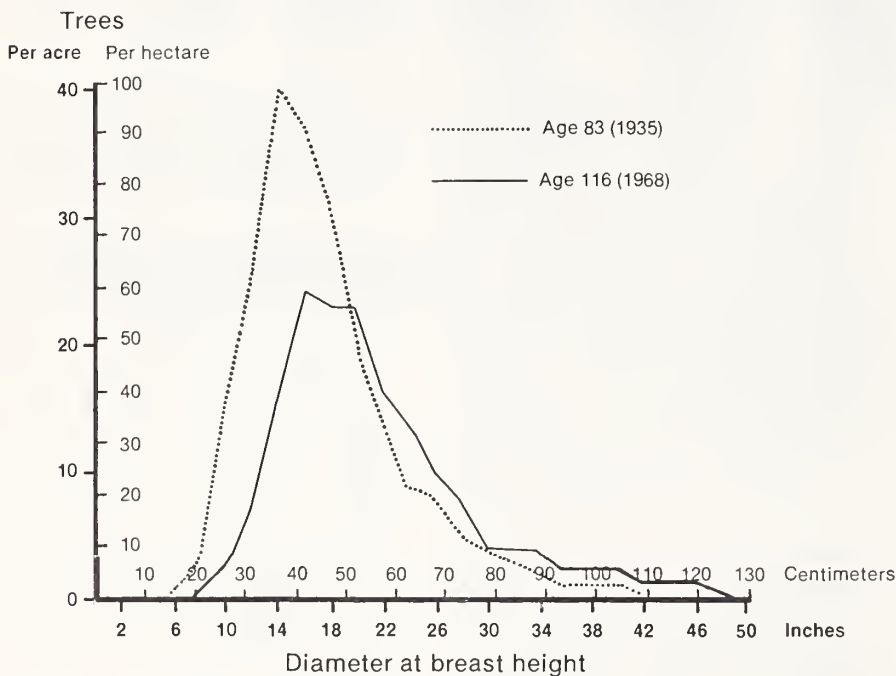
Figure 11.—Distribution of all species by
2-inch (5-cm) diameter class (trees
1.6+ inches (4+ cm) in d.b.h.).

Volume of Wood

The ability of mixed stands of Sitka
spruce and western hemlock to pro-
duce the yields of wood shown in fig-
ures 12-14 reflects their tremendous
potential for production of sawtimber
and wood fiber. These remarkable
yields can be attributed, in part, to the
complimentary growth habit of both
species and favorable site conditions.
A high productive capacity is indicated.
Western hemlock shows a slightly
greater productive advantage over
Sitka spruce for both cubic-foot and
board-foot (International 1/4-inch rule)
volumes, primarily because of the
smaller merchantable diameter limits
and the larger number of smaller west-
ern hemlock trees per acre (ha). For
board-foot volume (Scribner rule),
Sitka spruce and western hemlock
show almost identical yields. Figures
12-14 give average gross volumes with
no allowances for defect or breakage.
Figure 12 shows the average volumes
(Scribner rule) per acre and per hectare
for trees 11.6+ inches (29 cm) in d.b.h.
to a 6-inch (15-cm) top diameter. Total
volume per acre increased from an
average of 121,684 board feet at age
83 to 162,933 at age 116; individual
plot totals ranged from 95,878 to
167,439 board feet per acre at age 83
to 131,515 to 191,865 at age 116
(appendix tables 18 to 27). Board-foot
(International 1/4-inch rule) volume
per acre for trees 6.6+ inches (17 cm)
in d.b.h. to a 6.0-inch (15-cm) mer-
chantable top diameter is given in
figure 13. Total volume per unit area
rose from 138,522 board feet per acre
at age 83 to 178,957 at age 116. Indi-
vidual plot total volumes ranged from
112,812 to 179,040 board feet per acre
at age 83 to 146,864 to 205,342 board
feet per acre at age 116.

Figure 14 shows cubic volumes per
acre and hectare for trees 5.6+ inches
(14+ cm) in d.b.h. to a 4.0-inch
(10.2-cm) top diameter. Total volume
increased from 20,932 ft³/acre
(1465 m³/ha) at age 83 to 26,280 ft³/acre
(1839 m³/ha) at age 116.

Thousand board feet

Per acre   Per hectare
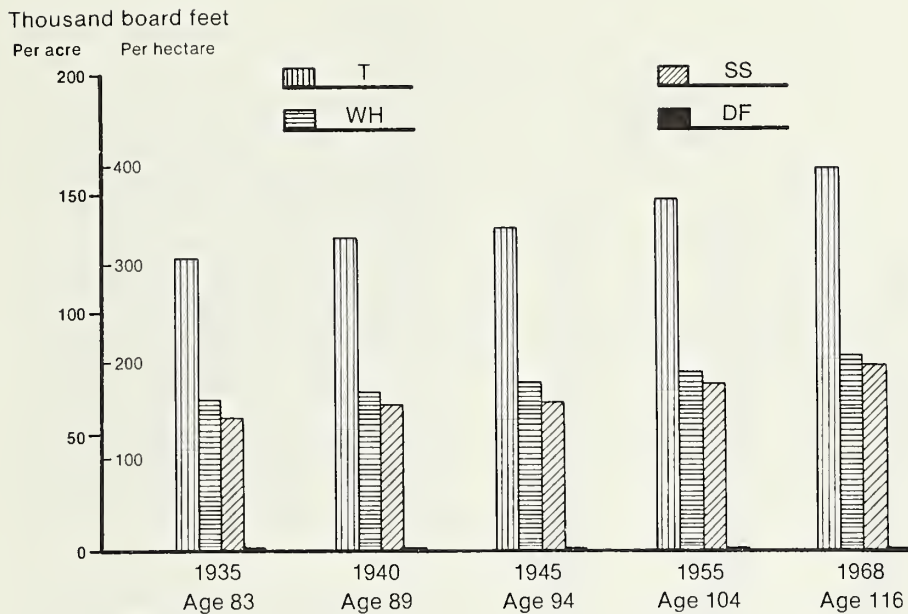
Figure 12.—Volume (Scribner rule) of western hemlock (WH), Sitka spruce (SS), Douglas-fir (DF), and all species (T), by year of measurement.

Thousand board feet

Per acre   Per hectare
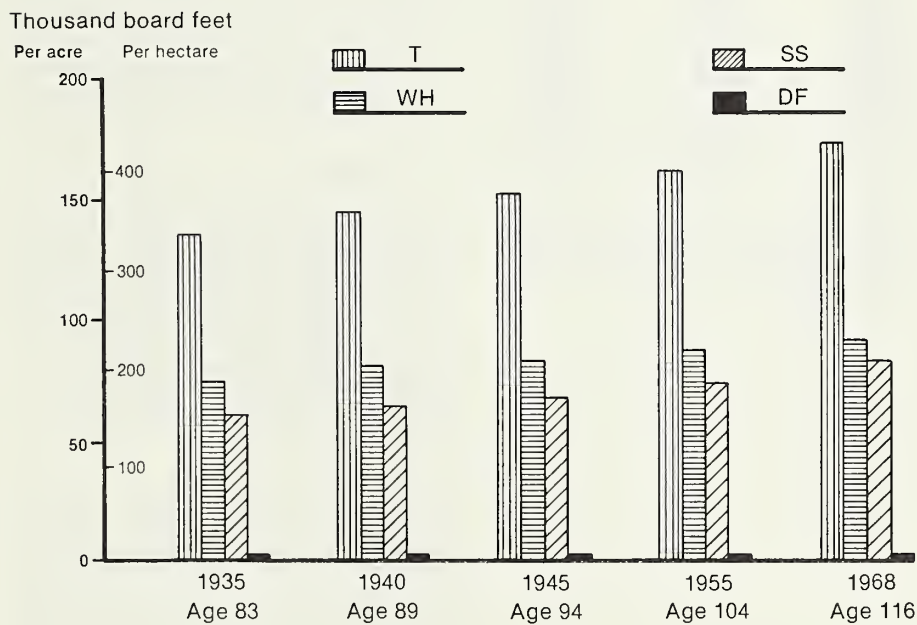
Figure 13.—Volume (International 1/4-inch rule) of western hemlock (WH), Sitka spruce (SS), Douglas-fir (DF), and all species (T), by year of measurement.

11
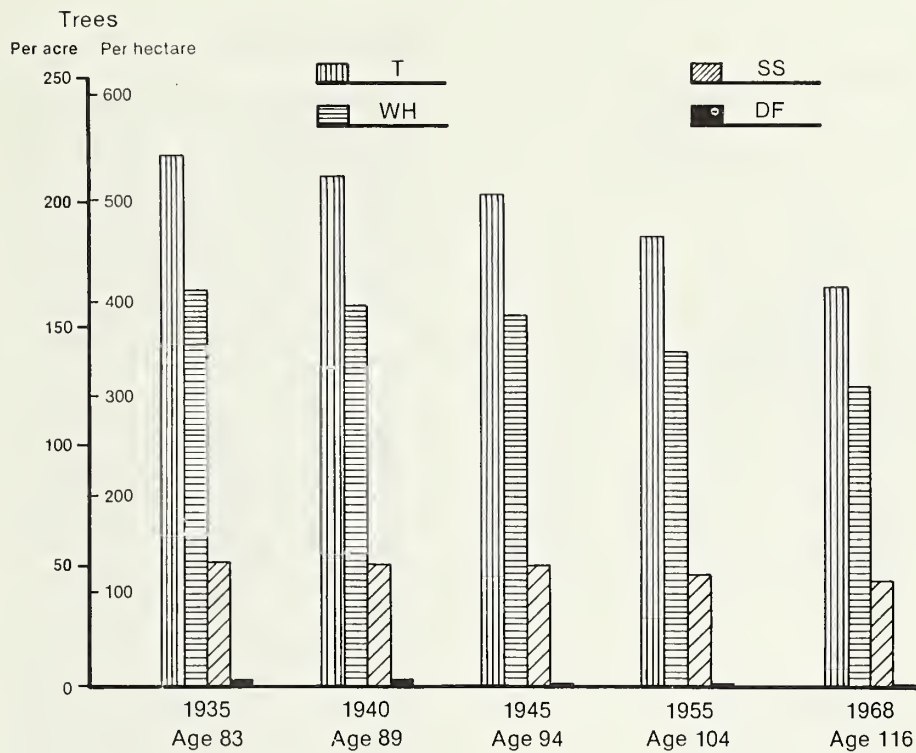
Figure 14.—Cubic volume of western hemlock (WH), Sitka spruce (SS), Douglas-fir (DF), and all species (T), by year of measurement.

Figure 15.—Mortality of trees 1.6+ inches (4+ cm) in d.b.h., 1935-68 (based on plots measured five times—plots 6 and 9 omitted).
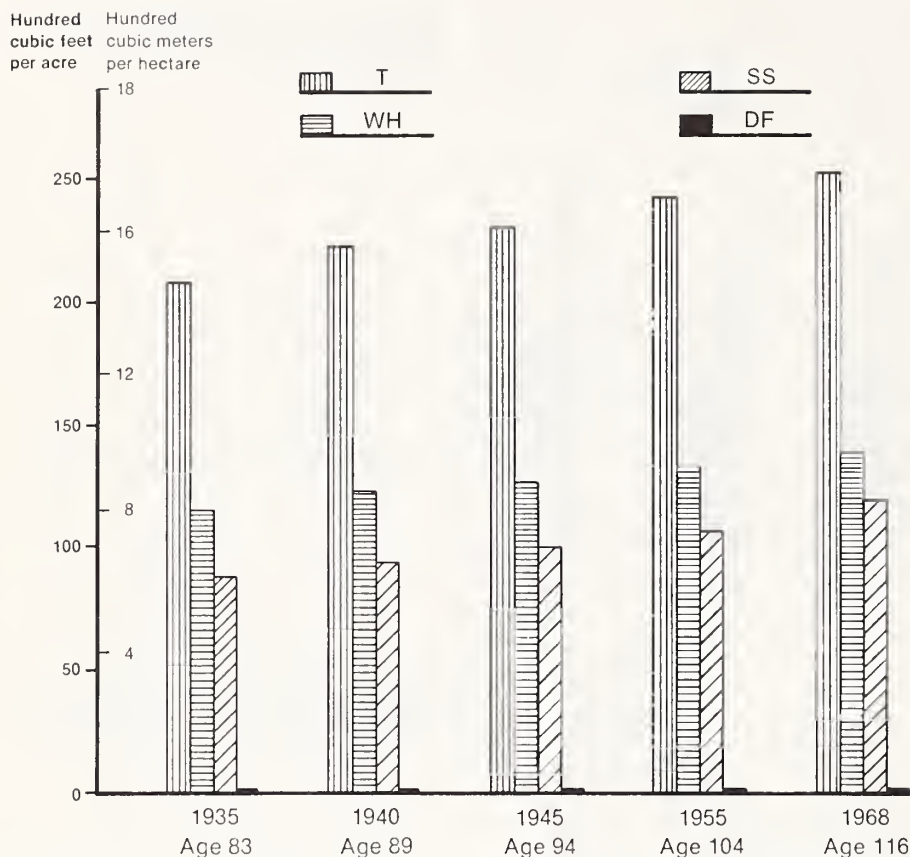
Mortality

Mortality for the permanent sample plots is shown in figure 15. Average mortality per acre (ha) ranged from slightly more than 7 trees/acre (18/ha) between ages 83 and 89 to 19/acre (47/ha) between ages 104 and 116 (appendix tables 28-29). A field measure in 1950 indicated that suppression and windfall were the primary causes of mortality, suppression contributing 79 percent of the total loss. Western hemlock has a higher rate of mortality than Sitka spruce (fig. 15). As the larger, dominant spruce subordinates the smaller, more tolerant hemlock, the weaker suppressed and intermediate hemlocks are eliminated from the stand.

Both Sitka spruce and western hemlock are species with shallow roots highly susceptible to windthrow (Meyer 1937). In fact, plot 6, which consisted of approximately 83 percent hemlock and 16 percent spruce, was completely destroyed during the 1962 Columbus Day windstorm.

Tree Growth

Estimates of mean annual and periodic annual gross increments per unit area for the study plots are given in appendix tables 30 and 31. Figures 16-18 give mean annual increment (MAI) and periodic annual increment (PAI) per acre for each species in board feet (International 1/4-inch and Scribner rules) and cubic feet.

The remarkably consistent growth habit of Sitka spruce is apparent. Mean annual increment for Sitka spruce averages 737 board feet per acre (International 1/4-inch rule) at age 83 and only decreases to 724 board feet at age 116, a reduction in annual growth of less than 2 percent. The MAI for western hemlock averages 915 board feet (International 1/4-inch rule) per acre at age 83 and decreases to 808 at age 116, a reduction of nearly 12 percent. The MAI for all species ranges from 1,669 board feet (International 1/4-inch rule) per acre at age 83 to 1,543 at age 116, the average growth rate declining only about 7 percent over the 33 years of measurement.

Thousand board feet

Per acre   Per hectare

—————— Mean annual increment

– – – – – Periodic annual increment
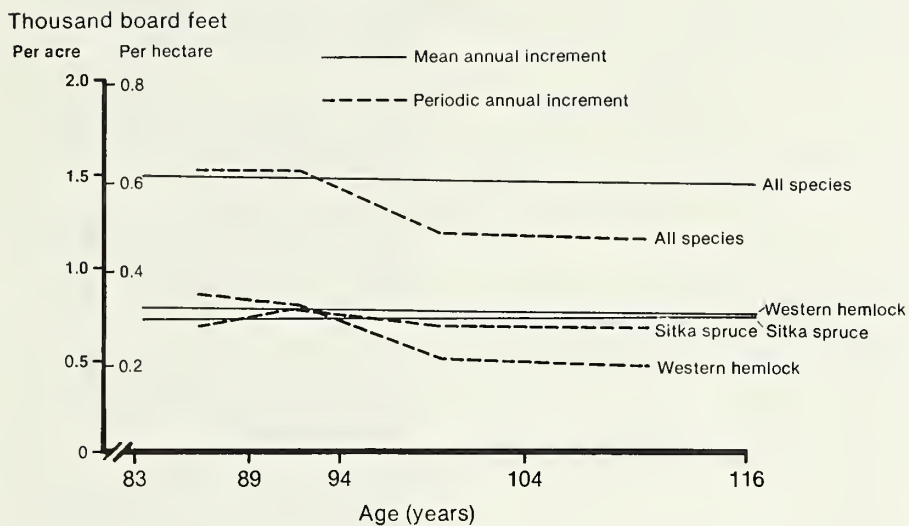
Figure 16.—Annual and periodic board-foot (Scribner rule) growth of trees 11.6 inches (29.5 cm) in d.b.h. to a 6-inch (15.2-cm) top diameter.

Thousand board feet

Per acre   Per hectare

—————— Mean annual increment

– – – – – Periodic annual increment
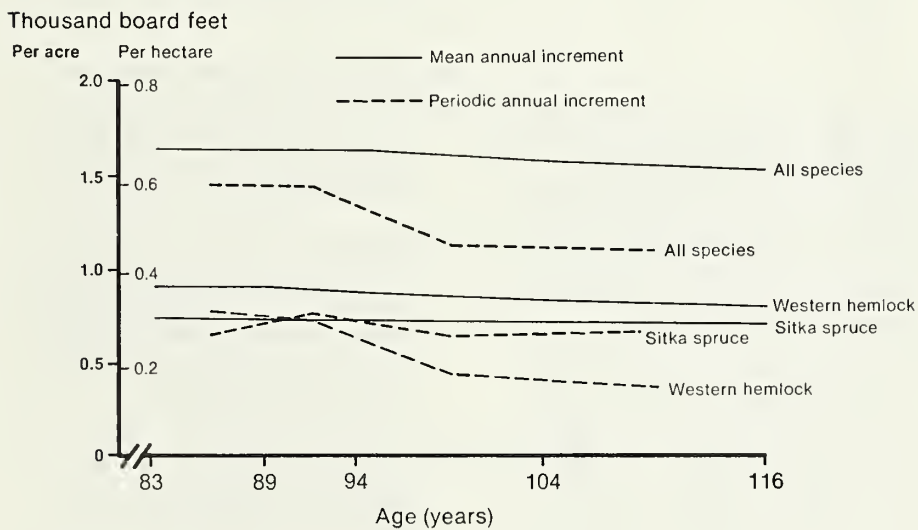
Figure 17.—Annual and periodic board-foot (International 1/4-inch rule) growth of trees 6.6+ inches (16.8+ cm) in d.b.h. to a 6-inch (15.2-cm) top diameter.

13

Cubic feet Cubic meters
per acre   per hectare

——————— Mean annual increment

— — — — Periodic annual increment

Figure 18.—Annual and periodic cubic volume growth of trees 5.6+ inches (14.2+ cm) in d.b.h. to a 4-inch (10.2-cm) top diameter.

Total wood production is at or near its maximum for the mixed stands of western hemlock and Sitka spruce at Cascade Head, but the culmination of MAI is not clearly defined for either species. Periodic annual increment is declining in relation to stand age. The sharp drop in PAI between the ages of 94 and 116 can be attributed to a corresponding reduction in the number of trees per acre (ha), especially in the intermediate and suppressed western hemlock crown classes. Periodic annual increment ranges from 789 board feet (International 1/4-inch rule) per acre to 396 for western hemlock between the ages of 83 and 116. For Sitka spruce, PAI appears to culminate at 776 board feet (International 1/4-inch rule) per acre between the ages of 89 and 94 and decreases gradually to 689 board feet between the ages of 104 and 116.

These data agree with the previous claim that the Sitka spruce–western hemlock type is among the most productive coniferous types in the world (Fujimori 1971).

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Appendix

Tables 5 to 31

Table 5—Summary of average height of selected trees, 1.6+ inches in d.b.h., 1935-68

Plot [1]	Western hemlock Height	Western hemlock No. of trees	Sitka spruce Height	Sitka spruce No. of trees	Douglas-fir Height	Douglas-fir No. of trees	All species Average height	All species No. of trees	Western hemlock Height	Western hemlock No. of trees	Sitka spruce Height	Sitka spruce No. of trees	Douglas-fir Height	Douglas-fir No. of trees	All species Average height	All species No. of trees
	Feet		Feet		Feet		Feet		Feet		Feet		Feet		Feet	
						1935								**1940**		
1	127	39	0	0	147	1	127	40	130	42	117	4	151	1	129	47
3	135	19	151	23	0	0	144	42	138	17	161	15	0	0	149	32
4	106	19	131	20	0	0	119	39	110	10	142	33	0	0	134	43
5	119	9	142	27	0	0	136	36	128	10	155	32	150	1	148	43
6	129	23	129	8	0	0	129	31	127	31	135	10	135	1	129	42
7	124	24	134	13	139	1	128	38	123	29	146	9	130	4	129	42
8	115	31	138	1	0	0	116	32	120	44	0	0	0	0	120	44
9	0	0	118	24	0	0	118	24	0	0	123	46	0	0	123	46
10	96	17	121	33	0	0	110	39	105	21	128	22	0	0	117	43
12	130	30	138	10	0	0	132	40	133	33	141	10	0	0	135	43
13	134	28	142	8	0	0	136	36	132	35	148	9	0	0	135	44
Total		239		156		2		397		272		190		7		469
Mean [2]	123		134		143		127		126		139		137		131	
				1945									**1955**			
1	133	41	0	0	0	0	133	41	137	37	137	3	165	1	138	41
3	134	21	162	33	0	0	151	54	142	26	170	22	0	0	155	48
4	107	11	137	28	0	0	128	39	115	16	144	30	131	3	133	49
5	127	10	155	31	0	0	148	41	129	10	160	32	149	1	152	43
6	124	29	141	9	0	0	128	38	139	30	151	12	135	1	142	43
7	132	30	152	10	139	1	137	41	129	27	145	12	136	4	134	43
8 [3] 9 [3]	124	41	0	0	0	0	124	41	123	34	147	2	0	0	124	36
10	103	23	130	22	0	0	116	45	117	26	139	25	0	0	128	51
12	139	24	148	9	0	0	141	33	140	28	148	12	0	0	142	40
13	137	30	150	9	0	0	140	39	142	28	163	8	0	0	147	36
Total		260		151		1		412		262		258		10		430
Mean [2]	128		148		139		135		132		152		138		139	
				1968												
1	143	53	142	3	164	1	144	57								
3	156	19	178	11	0	0	164	30								
4	124	15	153	24	141	1	142	40								
5 [4] 6 [4]	132	12	170	30	154	1	159	43								
7	135	28	160	11	142	4	142	43								
8	125	32	137	3	0	0	126	35								
10	127	20	149	26	0	0	140	46								
12	149	33	164	9	0	0	152	42								
13	148	31	172	10	0	0	154	41								
Total		243		127		7		377								
Mean [2]	139		161		147		147									

[1] Plots 2 and 11 are not included; plot 2 was destroyed soon after establishment, and plot 11 contained substantial amounts of young Douglas-fir and red alder.

[2] Weighted average, based on average height of trees on the plot times the number of observations per plot, summed over all plots with height measurements, and divided by the total number of observations.

[3] Plot 9 was destroyed by accidental logging.

[4] Plot 6 was destroyed by the 1962 Columbus Day storm.

Table 6—Summary of average height of selected trees, 4+ centimeters in d.b.h., 1935-68

Plot[1]	Western hemlock		Sitka spruce		Douglas-fir		All species		Western hemlock		Sitka spruce		Douglas-fir		All species	
	Height	No. of trees	Height	No. of trees	Height	No. of trees	Average height	No. of trees	Height	No. of trees	Height	No. of trees	Height	No. of trees	Average height	No. of trees
				1935								**1940**					
	Meters		Meters		Meters		Meters		Meters		Meters		Meters		Meters	
1	38.7	39	0	0	44.8	1	38.7	40	39.6	42	35.7	4	46.0	1	39.3	47
3	41.1	19	46.0	23	0	0	43.9	42	42.1	17	49.1	15	0	0	45.4	32
4	32.3	19	39.9	20	0	0	36.9	39	33.5	10	43.3	33	0	0	40.8	43
5	36.3	9	43.3	27	0	0	41.5	36	39.0	10	47.2	32	45.7	1	45.1	43
6	39.3	23	39.3	8	0	0	39.3	31	38.7	31	41.1	10	0	0	39.3	42
7	37.8	24	40.8	13	42.4	1	39.0	38	37.5	29	44.5	9	39.6	4	39.3	42
8	35.1	31	42.1	1	0	0	35.4	32	36.6	44	0	0	0	0	36.6	44
9	0	0	36.0	24	0	0	36.0	24	0	0	37.5	46	0	0	37.5	46
10	29.3	17	36.9	33	0	0	33.5	39	32.0	21	39.0	22	0	0	35.7	43
12	39.6	30	42.0	10	0	0	40.2	40	40.5	33	43.0	10	0	0	41.1	43
13	40.8	28	43.3	8	0	0	41.5	36	40.2	35	45.1	9	0	0	41.1	44
Total		239		156		2		397		272		190		7		469
Mean[2]	37.5		40.8		43.6		38.7		38.4		42.4		41.8		39.9	
				1945								**1955**					
1	40.5	41	0	0	0	0	40.5	41	41.8	37	41.8	3	50.3	1	42.1	41
3	40.8	21	49.4	33	0	0	46.0	54	43.3	26	51.8	22	0	0	47.2	48
4	32.6	11	41.8	28	0	0	39.0	39	35.1	16	43.9	30	39.9	3	40.5	49
5	38.7	10	47.2	31	0	0	45.1	41	39.3	10	48.8	32	45.4	1	46.3	43
6	37.8	29	43.0	9	0	0	39.0	38	42.4	30	46.0	12	39.0	1	43.3	43
7	40.2	30	46.3	10	42.4	1	41.8	41	39.3	27	44.2	12	41.5	4	40.8	43
8	37.8	41	0	0	0	0	37.8	41	37.5	34	44.8	2	0	0	37.8	36
9[3]																
10	31.4	23	39.6	22	0	0	35.4	45	35.7	26	42.4	25	0	0	39.0	51
12	42.4	24	45.1	9	0	0	43.0	33	42.7	28	45.1	12	0	0	43.3	40
13	41.8	30	45.7	9	0	0	42.7	39	43.3	28	49.7	8	0	0	44.8	36
Total		260		151		1		412		262		258		10		430
Mean[2]	39.0		45.1		42.4		41.1		40.2		46.3		42.1		42.4	
				1968													
1	43.6	53	43.3	3	50.0	1	43.9	57								
3	47.5	19	54.3	11	0	0	50.0	30								
4	37.8	15	46.6	24	43.0	1	43.3	40								
5	40.2	12	51.8	30	46.9	1	48.5	43								
6[4]																
7	41.2	28	48.8	11	43.3	4	43.3	43								
8	38.1	32	41.8	3	0	0	38.4	35								
10	38.7	20	45.4	26	0	0	42.7	46								
12	45.4	33	50.0	9	0	0	46.3	42								
13	45.1	31	52.4	10	0	0	46.9	41								
Total		243		127		7		377								
Mean[2]	42.4		49.1		44.8		44.8									

[1] Plots 2 and 11 are not included; plot 2 was destroyed soon after establishment, and plot 11 contained substantial amounts of young Douglas-fir and red alder.

[2] Weighted average, based on average height of trees on the plot times the number of observations per plot, summed over all plots with height measurements, and divided by the total number of observations.

[3] Plot 9 was destroyed by accidental logging.

[4] Plot 6 was destroyed by the 1962 Columbus Day storm.

Table 7—Stand description at age 83 in 1935, in English units[1]

Plot[2]	Basal area per acre[3]				Diameter[4]				Trees per acre[3]				Percent[5]
	WH	SS	DP	T	WH	SS	DP	T	WH	SS	DP	T	
	------ Square feet ------				-------- Inches --------				-------- Number --------				
1	407.2	9.9	3.4	420.5	16.9	17.4	25.0	17.0	260	6	1	267	97
3	153.3	264.0	.9	418.3	17.7	25.2	12.8	21.4	90	76	1	167	54
4	76.4	346.7	8.7	431.7	14.6	22.8	20.0	20.3	66	122	4	192	34
5	52.7	427.7	4.1	484.6	16.4	26.2	27.4	24.3	36	114	1	151	24
6	292.3	97.9	3.2	393.4	17.7	23.0	17.1	18.7	171	34	2	207	83
7	296.7	116.5	18.7	431.9	16.4	22.0	19.5	17.6	202	44	9	255	79
8	427.1	10.3	0	437.4	14.9	21.7	0	15.0	352	4	0	356	99
9	0	517.8	0	517.8	0	24.4	0	24.4	0	160	0	160	0
10	157.5	264.7	0	422.2	15.9	31.8	0	21.9	114	48	0	162	70
12	268.1	92.6	0	360.7	17.1	23.4	0	18.2	168	31	0	199	84
13	292.3	54.4	0	346.7	16.3	23.5	0	17.0	201	18	0	219	92
Mean[6]	236.8	176.3	4.0	417.1	16.2	25.1	20.3	18.7	165	51	2	218	76

[1] WH = western hemlock; SS = Sitka spruce; DF = Douglas-fir; T = total of all species.

[2] Plots 2 and 11 are not included; plot 2 was destroyed soon after establishment, and plot 11 contained substantial amounts of young Douglas-fir and red alder.

[3] Based on plot area of 1 horizontal acre.

[4] Quadratic mean diameter.

[5] Percent of western hemlock in designated plot.

[6] Based on plots intact in 1968--plots 6 and 9 omitted.

Table 8—Stand description at age 83 in 1935, in metric units[1]

Plot[2]	Basal area per hectare[3]				Diameter[4]				Trees per hectare[3]				Percent[5]
	WH	SS	DP	T	WH	SS	DP	T	WH	SS	DP	T	
	----- Square meters -----				------ Centimeters ------				-------- Number --------				
1	93.5	2.3	0.8	96.5	42.9	44.2	63.5	43.2	642	15	2	660	97
3	35.2	60.6	.2	96.0	45.0	64.0	32.5	54.4	222	188	2	413	54
4	17.5	79.6	2.0	99.1	37.1	57.9	50.8	51.6	163	301	10	474	34
5	12.1	98.2	.9	111.2	41.7	66.5	69.6	61.7	89	282	2	373	24
6	67.1	22.5	.7	90.3	45.0	58.4	43.4	47.5	423	84	5	511	83
7	68.1	26.7	4.3	99.1	41.7	55.9	49.5	44.7	499	109	22	630	79
8	98.0	2.4	0	100.4	37.8	55.1	0	38.1	870	10	0	880	99
9	0	118.9	0	118.9	0	62.0	0	62.0	0	395	0	395	0
10	36.2	60.8	0	96.9	40.4	80.8	0	55.6	282	119	0	400	70
12	61.5	21.3	0	82.8	43.4	59.4	0	46.2	415	77	0	492	80
13	67.1	12.5	0	79.6	41.4	59.7	0	43.2	497	44	0	541	92
Mean[6]	54.4	40.5	.9	95.8	41.1	63.8	51.6	47.5	408	126	5	539	76

[1] WH = western hemlock; SS = Sitka spruce; DF = Douglas-fir; T = total of all species.

[2] Plots 2 and 11 are not included; plot 2 was destroyed soon after establishment, and plot 11 contained substantial amounts of young Douglas-fir and red alder.

[3] Based on plot area of 1 horizontal hectare.

[4] Quadratic mean diameter.

[5] Percent of western hemlock in designated plot.

[6] Based on plots intact in 1968--plots 6 and 9 omitted.

Table 9—Stand description at age 89 in 1940, in English units[1]

Plot[2]	Basal area per acre[3]				Diameter[4]				Trees per acre[3]				Percent[5]
	WH	SS	DF	T	WH	SS	DF	T	WH	SS	DF	T	
	------- Square feet ------				-------- Inches --------				-------- Number --------				
1	423.1	9.2	3.6	435.9	17.5	18.4	25.7	17.6	253	5	1	259	98
3	154.4	267.7	.9	423.1	18.5	26.3	12.8	22.4	83	71	1	155	54
4	80.3	362.5	9.1	451.8	15.1	23.6	20.4	21.0	65	119	4	188	34
5	55.0	439.8	4.2	499.0	16.7	26.8	27.7	24.8	36	112	1	149	24
6	303.3	100.6	3.4	407.3	18.5	24.4	17.7	19.5	163	31	2	196	83
7	310.0	121.4	19.0	450.4	16.9	23.0	19.7	18.2	198	42	9	249	80
8	432.0	10.9	0	442.9	15.5	22.4	0	15.6	329	4	0	333	99
9	0	514.1	0	514.1	0	25.1	0	25.1	0	150	0	150	0
10	149.7	280.6	0	430.2	16.6	32.7	0	23.1	100	48	0	148	68
12	284.6	98.3	0	382.8	17.7	24.5	0	18.9	166	30	0	196	85
13	306.6	56.8	0	363.4	16.9	25.5	0	17.7	197	16	0	213	92
Mean[6]	244.0	183.0	4.1	431.1	16.8	26.0	20.5	19.4	159	50	2	211	75

[1] WH = western hemlock; SS = Sitka spruce; DF = Douglas-fir; T = total of all species.

[2] Plots 2 and 11 are not included; plot 2 was destroyed soon after establishment, and plot 11 contained substantial amounts of young Douglas-fir and red alder.

[3] Based on plot area of 1 horizontal acre.

[4] Quadratic mean diameter.

[5] Percent of western hemlock in designated plot.

[6] Based on plots intact in 1968—plots 6 and 9 omitted.

Table 10—Stand description at age 89 in 1940, in metric units[1]

Plot[2]	Basal area per hectare[3]				Diameter[4]				Trees per hectare[3]				Percent[5]
	WH	SS	DF	T	WH	SS	DF	T	WH	SS	DF	T	
	----- Square meters -----				------ Centimeters -------				-------- Number --------				
1	97.1	2.1	0.8	100.1	44.5	46.7	65.3	44.7	625	12	2	640	98
3	35.4	61.5	.2	97.1	47.0	66.8	32.5	56.9	205	175	2	383	54
4	18.4	83.2	2.1	103.7	38.4	59.9	51.8	53.3	161	294	10	465	34
5	12.6	101.0	1.0	114.5	42.4	68.1	70.4	63.0	89	277	2	368	24
6	69.6	23.1	.8	93.5	47.0	62.0	45.0	49.5	403	77	5	484	83
7	71.2	27.9	4.4	103.4	42.9	58.4	50.0	46.2	489	104	22	615	80
8	99.2	2.5	0	101.7	39.4	56.9	0	39.6	813	10	0	823	99
9	0	118.0	0	118.0	0	63.8	0	63.8	0	371	0	371	0
10	34.4	64.4	0	98.8	42.2	83.1	0	58.7	247	119	0	366	68
12	65.3	22.6	0	87.9	45.0	62.2	0	48.0	410	74	0	484	85
13	70.4	13.0	0	83.4	42.9	64.8	0	45.0	487	40	0	526	92
Mean[6]	56.0	42.0	.9	99.0	42.7	66.0	52.1	49.3	393	124	5	521	75

[1] WH = western hemlock; SS = Sitka spruce; DF = Douglas-fir; T = total of all species.

[2] Plots 2 and 11 are not included; plot 2 was destroyed soon after establishment, and plot 11 contained substantial amounts of young Douglas-fir and red alder.

[3] Based on plot area of 1 horizontal hectare.

[4] Quadratic mean diameter.

[5] Percent of western hemlock in designated plot.

[6] Based on plots intact in 1968—plots 6 and 9 omitted.

Table 11—Stand description at age 94 in 1945, in English units[1]

Plot[2]	Basal area per acre[3]				Diameter[4]				Trees per acre[3]				Percent[5]
	WH	SS	DF	T	WH	SS	DF	T	WH	SS	DF	T	
	------- Square feet ------				--------- Inches ---------				-------- Number --------				
1	463.3	8.5	3.8	448.6	18.1	19.7	26.4	18.2	244	4	1	249	98
3	156.0	281.D	.9	437.9	19.1	27.1	12.8	23.2	78	70	1	149	52
4	84.1	362.5	9.2	469.6	15.4	24.3	20.5	21.5	65	117	4	186	35
5	56.3	448.2	4.3	508.8	17.2	27.3	28.1	25.3	35	110	1	146	24
6	309.6	105.5	3.4	418.5	19.1	25.4	17.7	20.3	155	30	2	187	83
7	316.0	125.3	13.4	454.7	17.4	23.7	2D.2	18.7	192	41	6	239	80
8	443.7	11.6	0	455.2	16.0	23.1	0	16.1	317	4	0	321	99
10	153.7	294.6	0	448.3	16.9	33.5	0	23.6	99	48	0	147	67
12	282.0	103.2	0	385.3	18.3	25.5	0	19.6	155	29	0	184	84
13	312.0	61.6	0	373.7	17.4	26.6	0	18.3	189	16	0	205	92
Mean[6]	248.9	190.0	3.5	442.5	17.3	26.7	21.1	20.D	153	49	1	203	75

[1] WH = western hemlock; SS = Sitka spruce; DF = Douglas-fir; T = total of all species.

[2] Plots 2, 9, and 11 are not included; plot 2 was destroyed soon after establishment, plot 9 was accidentally destroyed by logging, and plot 11 contained substantial amounts of young Douglas-fir and red alder.

[3] Based on plot area of 1 horizontal acre.

[4] Quadratic mean diameter.

[5] Percent of western hemlock in designated plot.

[6] Based on plots intact in 1968--plot 6 omitted.

Table 12—Stand description at age 94 in 1945, in metric units[1]

Plot[2]	Basal area per hectare[3]				Diameter[4]				Trees per hectare[3]				Percent[5]
	WH	SS	DF	T	WH	SS	DF	T	WH	SS	DF	T	
	----- Square meters ------				------- Centimeters ------				-------- Number ---------				
1	106.4	2.0	0.9	103.0	46.0	50.0	67.1	46.2	603	10	2	615	98
3	35.8	64.5	.2	100.5	48.5	68.8	32.5	58.9	193	173	2	368	52
4	19.3	83.2	2.1	107.8	39.1	61.7	52.1	54.6	161	289	10	460	35
5	12.9	102.9	1.0	116.8	43.7	69.3	71.4	64.3	86	272	2	361	24
6	71.1	24.2	.8	96.1	48.5	64.5	45.0	51.6	383	74	5	462	83
7	72.5	28.8	3.1	104.4	44.2	60.2	51.3	47.5	474	101	15	591	80
8	101.9	2.7	0	104.5	4D.6	58.7	0	4D.9	783	10	0	793	99
10	35.3	67.6	0	103.0	142.9	85.1	0	59.9	1245	119	0	363	67
12	64.7	23.7	0	88.4	146.5	64.8	0	49.8	1383	72	0	455	84
13	71.6	14.1	0	85.8	144.2	67.6	0	46.5	1467	40	0	507	92
Mean[6]	57.1	43.6	.8	101.6	43.9	67.8	53.6	50.8	378	121	2	502	75

[1] WH = western hemlock; SS = Sitka spruce; DF = Douglas-fir; T = total of all species.

[2] Plots 2, 9, and 11 are not included; plot 2 was destroyed soon after establishment, plot 9 was accidentally destroyed by logging, and plot 11 contained substantial amounts of young Douglas-fir and red alder.

[3] Based on plot area of 1 horizontal hectare.

[4] Quadratic mean diameter.

[5] Percent of western hemlock in designated plot.

[6] Based on plots intact in 1968--plot 6 omitted.

Table 13—Stand description at age 104 in 1955, in English units[1]

Plot[2]	Basal area per acre[3]				Diameter[4]				Trees per acre[3]				Percent[5]
	WH	SS	OP	T	WH	SS	DP	T	WH	SS	DP	T	
	------- Square feet -------				---------- Inches --------				--------- Number --------				
1	430.6	8.3	4.1	443.0	19.0	22.5	27.4	19.1	218	3	1	222	98
3	152.2	301.3	0	453.5	20.1	28.7	0	24.7	69	67	0	136	51
4	90.4	399.2	9.6	499.3	16.1	25.7	21.0	22.6	64	111	4	179	36
5	58.2	445.6	4.4	508.2	18.0	29.0	28.4	26.7	33	97	1	131	25
6	325.4	113.9	2.2	441.5	20.0	36.8	20.1	21.3	149	29	1	179	83
7	331.9	138.6	10.7	481.2	18.1	24.9	19.8	19.5	185	41	5	231	80
8	445.0	10.7	0	455.7	16.9	25.6	0	17.0	285	3	0	288	99
10	139.4	321.1	0	460.6	117.5	35.4	0	25.5	83	47	0	130	64
12	299.9	113.6	0	413.5	119.3	27.8	0	20.8	148	27	0	175	84
13	313.6	65.3	0	378.9	118.5	30.3	0	19.6	168	13	0	181	93
Mean[6]	251.2	200.4	3.2	454.9	18.2	28.4	21.9	21.2	139	45	1	185	75

[1] WH = western hemlock; SS = Sitka spruce; DP = Douglas-fir; T = total of all species.

[2] Plots 2, 9, and 11 are not included; plot 2 was destroyed soon after establishment, plot 9 was accidentally destroyed by logging, and plot 11 contained substantial amounts of young Douglas-fir and red alder.

[3] Based on plot area of 1 horizontal acre.

[4] Quadratic mean diameter.

[5] Percent of western hemlock in designated plot.

[6] Based on plots intact in 1968--plot 6 omitted.

Table 14—Stand description at age 104 in 1955, in metric units[1]

Plot[2]	Basal area per hectare[3]				Diameter[4]				Trees per hectare[3]				Percent[5]
	WH	SS	OP	T	WH	SS	DP	T	WH	SS	DP	T	
	----- Square meters -----				------- Centimeters ------				--------- Number ---------				
1	98.8	1.9	.9	101.7	48.3	57.2	69.6	48.5	539	7	2	549	98
3	34.9	69.2	0	104.1	51.1	72.9	0	62.7	171	166	0	336	51
4	20.8	91.6	2.2	114.6	40.9	65.3	53.3	57.4	158	274	10	442	36
5	13.4	102.3	1.0	116.7	45.7	73.7	72.1	67.8	82	240	2	324	25
6	74.7	26.1	.5	101.3	50.8	93.5	51.1	54.1	368	72	2	442	83
7	76.2	31.8	2.5	110.5	46.0	63.2	50.3	49.5	457	101	12	571	80
8	102.2	2.5	0	104.6	42.9	65.0	0	43.2	704	7	0	712	99
10	32.0	73.7	0	105.7	44.5	89.9	0	64.8	205	116	0	321	64
12	68.8	26.1	0	94.9	49.0	70.6	0	52.8	366	67	0	432	84
13	72.0	15.0	0	87.0	47.0	77.0	0	49.8	415	32	0	447	93
Mean[6]	57.7	46.0	.7	104.4	46.2	72.1	55.6	53.8	343	111	2	457	75

[1] WH = western hemlock; SS = Sitka spruce; DP = Douglas-fir; T = total of all species.

[2] Plots 2, 9, and 11 are not included; plot 2 was destroyed soon after establishment, plot 9 was accidentally destroyed by logging, and plot 11 contained substantial amounts of young Douglas-fir and red alder.

[3] Based on plot area of 1 horizontal hectare.

[4] Quadratic mean diameter.

[5] Percent of western hemlock in designated plot.

[6] Based on plots intact in 1968--plot 6 omitted.

Table 15—Stand description at age 116 in 1968, in English units[1]

Plot[2]	Basal area per acre[3]				Diameter[4]				Trees per acre[3]				
	WH	SS	DF	T	WH	SS	DF	T	WH	SS	DF	T	Percent[5]
	------- Square feet ------				-------- Inches --------				--------- Number -------				
1	423.5	8.8	4.4	436.7	20.2	23.2	28.4	20.3	190	3	1	194	98
3	152.8	319.5	0	472.3	21.3	30.7	0	26.4	62	62	0	124	50
4	92.8	429.5	8.2	530.5	17.6	27.7	22.4	24.6	55	103	3	161	34
5	60.3	452.9	4.7	517.9	19.2	30.7	29.4	28.2	30	88	1	119	25
7	325.6	148.7	12.0	486.4	19.3	27.5	21.0	21.0	161	36	5	202	80
8	457.6	11.7	0	469.3	18.0	26.7	0	18.1	259	3	0	262	99
10	125.4	347.9	0	473.4	19.1	37.2	0	28.2	63	46	0	109	58
12	316.3	120.2	0	436.5	20.6	31.7	0	22.4	137	22	0	159	86
13	313.0	75.3	0	388.3	19.8	32.6	0	21.2	146	13	0	159	92
Mean[6]	251.9	212.7	3.3	467.9	19.4	30.6	23.2	22.8	123	42	1	166	74

[1] WH = western hemlock; SS = Sitka spruce; DF = Douglas-fir; T = total of all species.

[2] Plots 2, 6, 9, and 11 are not included; plot 2 was destroyed soon after establishment, plot 6 was destroyed by the substantial amounts Columbus Day storm (before remeasurement), plot 9 was accidentally destroyed by logging, and plot 11 contained substantial amounts of young Douglas-fir and red alder.

[3] Based on plot area of 1 horizontal acre.

[4] Quadratic mean diameter.

[5] Percent of western hemlock in designated plot.

[6] Based on plot intact in 1968.

Table 16—Stand description at age 116 in 1968, in metric units[1]

Plot[2]	Basal area per hectare[3]				Diameter[4]				Trees per hectare[3]				
	WH	SS	DF	T	WH	SS	DF	T	WH	SS	OF	T	Percent[5]
	----- Square meters -----				------ Centimeters -------				--------- Number --------				
1	97.2	2.0	1.0	100.2	51.3	58.9	72.1	51.6	469	7	2	479	98
3	35.1	73.3	0	108.4	54.1	78.0	0	67.1	153	153	0	306	50
4	21.3	98.6	1.9	121.8	44.7	70.4	56.9	62.5	136	255	7	398	34
5	13.8	104.0	1.1	118.9	48.8	78.0	74.7	71.6	74	217	2	294	25
7	74.7	34.1	2.8	111.7	49.0	69.9	53.3	53.3	398	89	12	499	80
8	105.0	2.7	0	107.7	45.7	67.8	0	46.0	640	7	0	647	99
10	28.8	79.9	0	108.7	48.5	94.5	0	71.6	156	114	0	269	58
12	72.6	27.6	0	100.2	52.3	80.5	0	56.9	339	54	0	393	86
13	71.9	17.3	0	89.1	50.3	82.8	0	53.8	361	32	0	393	92
Mean[6]	57.8	48.8	.8	107.4	49.3	77.7	58.9	57.9	304	104	2	410	74

[1] WH = western hemlock; SS = Sitka spruce; DF = Douglas-fir; T = total of all species.

[2] Plots 2, 6, 9, and 11 are not included; plot 2 was destroyed soon after establishment, plot 6 was destroyed by the 1962 Columbus Day storm (before remeasurement), plot 9 was accidentally destroyed by logging, and plot 11 contained substantial amounts of young Douglas-fir and red alder.

[3] Based on plot area of 1 horizontal hectare.

[4] Quadratic mean diameter.

[5] Percent of western hemlock in designated plot.

[6] Based on plots intact in 1968.

Table 17—Number of trees by 2-inch diameter class, year of measurement, and species for trees 1.6+ inches

Year, age (years), and species	Diameter at breast height (inches[1])																									Total[2]
	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	
1935 (83):																										
Western hemlock	0	0	0	2	14	23	37	33	25	15	8	4	2	0	0	0	0	0	0	0	0	0	0	0	0	163
Sitka spruce	0	0	0	0	0	1	3	4	5	5	5	5	6	4	4	3	2	1	1	1	0	0	0	0	0	50
Douglas-fir	0	0	0	0	1	0	0	0	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	4
All species[2]	0	0	0	2	15	24	40	37	31	20	14	9	8	5	4	3	2	1	1	1	0	0	0	0	0	217
1940 (89):																										
Western hemlock	0	0	0	1	11	21	31	31	28	16	10	5	3	1	0	0	0	0	0	0	0	0	0	0	0	158
Sitka spruce	0	0	0	0	0	1	3	3	5	4	5	5	5	4	4	3	3	1	1	1	1	0	0	0	0	49
Douglas-fir	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2
All species[2]	0	0	0	1	11	22	34	34	33	21	16	10	8	5	4	3	3	1	1	1	1	0	0	0	0	209
1945 (94):																										
Western hemlock	0	0	0	1	9	17	29	29	28	17	13	6	3	2	0	0	0	0	0	0	0	0	0	0	0	154
Sitka spruce	0	0	0	0	0	0	2	3	5	4	4	6	5	5	4	3	3	2	1	1	1	0	0	0	0	49
Douglas-fir	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
All species[2]	0	0	0	1	9	17	31	32	33	21	17	12	8	7	4	3	3	2	1	1	1	0	0	0	0	203
1955 (104):																										
Western hemlock	0	0	0	0	5	12	21	27	24	20	12	8	5	2	1	0	0	0	0	0	0	0	0	0	0	137
Sitka spruce	0	0	0	0	0	0	1	2	4	3	4	4	5	4	4	3	3	3	1	1	1	1	0	0	0	44
Douglas-fir	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
All species[2]	0	0	0	0	5	12	22	29	28	23	16	12	10	6	5	3	3	3	1	1	1	1	0	0	0	181
1968 (116):																										
Western hemlock	0	0	0	0	2	7	15	22	20	21	13	10	7	3	1	1	0	0	0	0	0	0	0	0	0	122
Sitka spruce	0	0	0	0	0	0	0	2	3	2	3	4	3	5	3	3	4	2	2	2	1	1	1	0	0	41
Douglas-fir	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
All species[2]	0	0	0	0	2	7	15	24	23	23	16	14	10	8	4	4	4	2	2	2	1	1	1	0	0	163

[1] To convert inches to centimeters, multiply by 2.54.

[2] Totals in this table are for plots 1, 3, 4, 5, 7, 8, 10, 12, and 13.

Table 18—Volume per acre at age 83 in 1935

Plot [1]	Western hemlock			Sitka spruce			Douglas-fir			All species		
	Board feet [2]	Board feet [3]	Cubic feet [4]	Board feet [2]	Board feet [3]	Cubic feet [4]	Board feet [2]	Board feet [3]	Cubic feet [4]	Board feet [2]	Board feet [3]	Cubic feet [4]
1	112,449	132,762	20,366	2,821	3,202	490	1,091	1,179	171	116,361	137,143	21,027
3	43,222	50,689	7,706	83,626	91,739	13,399	194	244	41	129,743	142,672	21,146
4	18,289	23,461	3,741	109,526	119,003	17,492	2,570	2,908	433	130,385	145,373	21,666
5	13,983	16,983	2,624	141,343	149,049	21,748	1,371	1,453	210	156,697	167,485	24,582
6	83,343	96,687	14,693	31,026	33,577	4,939	899	1,044	159	115,268	131,308	19,791
7	80,209	95,649	14,782	36,256	39,757	5,865	5,641	6,303	930	122,105	141,710	21,578
8	103,959	132,252	20,994	3,194	3,505	517	399	581	95	107,553	136,338	21,607
9				167,439	179,040	6,228	0	0	0	167,439	179,040	26,228
10	40,997	50,142	7,813	91,467	93,449	13,563	0	0	0	132,469	143,591	21,375
12	74,463	87,685	13,422	29,504	31,891	4,682	0	0	0	103,967	119,576	18,104
13	78,449	94,069	14,554	17,428	18,743	2,751	0	0	0	95,878	112,812	17,305
Mean [5]	62,891	75,966	11,778	57,541	61,149	8,945	1,252	1,408	209	121,684	138,522	20,932

[1] Plots 2 and 11 are not included; plot 2 was destroyed soon after establishment, and plot 11 contained substantial amounts of young Douglas-fir and red alder.

[2] Scribner rule, trees 11.6+ inches in d.b.h. to a 6-inch top diameter.

[3] International 1/4-inch rule, trees 6.6+ inches in d.b.h. to a 6-inch top diameter.

[4] Trees 5.6+ inches in d.b.h. to a 4-inch top diameter.

[5] Based on plots intact in 1968--plots 6 and 9 omitted.

Table 19—Volume per hectare at age 83 in 1935

Plot [1]	Western hemlock	Sitka spruce	Douglas-fir	Total
	Cubic meters [2]			
1	1425	34	12	1471
3	539	938	3	1480
4	262	1224	30	1516
5	184	1522	15	1720
6	1028	346	11	1385
7	1034	410	65	1510
8	1469	36	7	1512
9	0	436	0	1835
10	547	949	0	1496
12	939	328	0	1267
13	1018	192	0	1211
Mean [3]	824	626	15	1465

[1] Plots 2 and 11 are not included; plot 2 was destroyed soon after establishment, and plot 11 contained substantial amounts of young Douglas-fir and red alder.

[2] Trees 14+ centimeters in d.b.h. to a 10.2-centimeter top diameter.

[3] Based on plots intact in 1968--plots 6 and 9 omitted.

Table 20—Volume per acre at age 89 in 1940

Plot[1]	Western hemlock			Sitka spruce			Douglas-fir			All species		
	Board feet[2]	Board feet[3]	Cubic feet[4]	Board feet[2]	Board feet[3]	Cubic feet[4]	Board feet[2]	Board feet[3]	Cubic feet[4]	Board feet[2]	Board feet[3]	Cubic feet[4]
1	121,115	141,924	21,613	2,740	3,075	465	1,186	1,278	185	125,041	146,277	22,263
3	45,712	52,585	7,932	90,267	95,552	13,889	207	260	44	136,187	148,397	21,864
4	20,213	25,470	4,021	118,140	127,803	18,699	2,772	3,128	464	141,126	156,401	23,183
5	15,178	18,190	2,796	149,040	157,039	22,838	1,421	1,508	218	165,639	176,736	25,852
6	90,087	103,406	15,582	33,179	35,585	5,197	967	1,119	170	124,234	140,110	20,950
7	87,117	102,857	15,775	39,217	42,650	6,254	5,872	6,565	968	132,306	152,072	22,998
8	111,343	138,572	21,737	3,485	3,812	560	433	646	105	115,261	143,030	22,402
9	--	--	--	170,941	182,286	26,606	0	0	0	170,941	182,286	26,606
10	41,019	49,260	5,795	99,369	101,446	14,677	0	0	0	140,389	150,707	22,272
12	82,198	95,828	14,555	32,498	34,788	4,079	0	0	0	114,696	130,617	19,634
13	85,677	101,629	15,595	18,971	20,223	2,944	0	0	0	104,648	121,852	18,539
Mean[5]	67,730	80,702	12,402	61,525	65,154	9,489	1,321	1,487	220	130,577	147,343	22,112

[1] Plots 2 and 11 are not included; plot 2 was destroyed soon after establishment, and plot 11 contained substantial amounts of young Douglas-fir and red alder.

[2] Scribner rule, trees 11.6+ inches in d.b.h. to a 6-inch top diameter.

[3] International 1/4-inch rule, trees 6.6+ inches in d.b.h. to a 6-inch top diameter.

[4] Trees 5.6+ inches in d.b.h. to a 4-inch top diameter.

[5] Based on plots intact in 1968--plots 6 and 9 omitted.

Table 21—Volume per hectare at age 89 in 1940

Plot[1]	Western hemlock	Sitka spruce	Douglas-fir	All species
		Cubic meters[2]		
1	1512	33	13	1558
3	555	972	3	1530
4	281	1308	32	1622
5	196	1598	15	1809
6	1090	364	12	1466
7	1104	438	68	1609
8	1521	39	7	1567
9	0	1862	0	1862
10	405	1027	0	1558
12	1018	285	0	1374
13	1091	206	0	1297
Mean[3]	868	664	15	1547

[1] Plots 2 and 11 are not included; plot 2 was destroyed soon after establishment, and plot 11 contained substantial amounts of young Douglas-fir and red alder.

[2] Trees 14+ centimeters in d.b.h. to a 10.2-centimeter top diameter.

[3] Based on plots intact in 1968--plots 6 and 9 omitted.

Table 22—Volume per acre at age 94 in 1945

Plot[1]	Western hemlock			Sitka spruce			Douglas-fir			All species		
	Board feet [2]	Board feet [3]	Cubic feet [4]	Board feet [2]	Board feet [3]	Cubic feet [4]	Board feet [2]	Board feet [3]	Cubic feet [4]	Board feet [2]	Board feet [3]	Cubic feet [4]
1	129,200	150,028	22,692	2,663	2,946	440	1,281	1,377	199	133,144	154,351	23,331
3	47,954	54,430	8,157	96,992	102,368	14,836	215	269	45	145,161	157,067	23,037
4	21,838	27,320	4,285	125,746	135,509	19,760	2,876	3,244	480	150,461	166,073	24,526
5	16,204	19,064	2,913	154,961	163,105	23,671	1,478	1,570	226	172,643	183,739	26,810
6	95,054	108,106	16,186	35,751	38,153	5,550	995	1,152	175	131,801	147,412	21,912
7	91,498	107,278	16,363	41,454	44,945	6,568	4,285	4,744	694	137,237	156,968	23,625
8	119,304	146,258	22,746	3,797	4,131	605	0	134	27	123,101	150,523	23,377
10	43,401	51,669	7,933	106,398	108,523	15,672	0	0	0	149,799	160,193	23,605
12	83,920	97,226	14,681	35,093	37,365	5,434	0	0	0	119,012	134,591	20,115
13	90,086	105,976	16,157	21,136	22,403	3,251	0	0	0	111,222	128,380	19,408
Mean[5]	71,489	84,361	12,881	65,360	69,033	10,026	1,126	1,260	186	137,976	154,654	23,093

[1] Plots 2, 9, and 11 are not included; plot 2 was destroyed soon after establishment, plot 9 was accidentally destroyed by logging, and plot 11 contained substantial amounts of young Douglas-fir and red alder.

[2] Scribner rule, trees 11.6+ inches in d.b.h. to a 6-inch top diameter.

[3] International 1/4-inch rule, trees 6.6+ inches in d.b.h. to a 6-inch top diameter.

[4] Trees 5.6+ inches in d.b.h. to a 4-inch top diameter.

[5] Based on plots intact in 1968—plot 6 omitted.

Table 23—Volume per hectare at age 94 in 1945

Plot[1]	Western hemlock	Sitka spruce	Douglas-fir	All species
		Cubic meters[2]		
1	1588	31	14	1633
3	571	1038	3	1612
4	300	1383	34	1716
5	204	1656	16	1876
6	1133	388	12	1533
7	1145	460	49	1653
8	1592	42	2	1636
10	555	1097	0	1652
12	1027	380	0	1407
13	1131	227	0	1358
Mean[3]	901	702	13	1616

[1] Plots 2, 9, and 11 are not included; plot 2 was destroyed soon after establishment, plot 9 was accidentally destroyed by logging, and plot 11 contained substantial amounts of young Douglas-fir and red alder.

[2] Trees 14+ centimeters in d.b.h. to a 10.2-centimeter top diameter.

[3] Based on plots intact in 1968—plot 6 omitted.

Table 24—Volume per acre at age 104 in 1955

Plot[1]	Western hemlock			Sitka spruce			Douglas-fir			All species		
	Board feet [2]	Board feet [3]	Cubic feet [4]	Board feet [2]	Board feet [3]	Cubic feet [4]	Board feet [2]	Board feet [3]	Cubic feet [4]	Board feet [2]	Board feet [3]	Cubic feet [4]
1	134,600	154,344	23,137	2,791	3,050	488	1,448	1,553	223	138,840	158,946	23,808
3	49,164	55,292	8,220	108,490	114,143	16,462	0	0	0	157,654	169,435	24,682
4	24,862	30,721	4,767	139,623	149,725	21,708	3,117	3,513	518	167,602	183,960	26,993
5	17,718	20,521	3,108	160,835	168,612	24,359	1,584	1,686	242	180,137	190,819	27,709
6	104,444	118,091	17,561	40,354	42,865	6,204	714	B12	120	145,512	161,768	23,886
7	101,226	117,345	17,750	48,001	51,784	7,526	3,511	3,906	571	152,739	173,045	25,848
8	128,022	153,854	23,618	3,730	4,018	582	0	0	0	131,752	157,873	24,200
10	41,451	48,810	7,431	120,420	122,760	17,666	0	0	0	161,870	171,570	25,097
12	94,276	107,856	16,134	40,658	42,920	6,201	0	0	0	134,934	150,777	22,335
13	96,403	111,550	16,806	23,766	24,831	3,575	0	0	0	120,168	136,381	20,381
Mean[5]	76,414	88,922	13,441	72,035	75,760	10,947	1,073	1,184	173	149,522	165,867	24,561

[1] Plots 2, 9, and 11 are not included; plot 2 was destroyed soon after establishment, plot 9 was accidentally destroyed by logging, and plot 11 contained substantial amounts of young Douglas-fir and red alder.

[2] Scribner rule, trees 11.6+ inches in d.b.h. to a 6-inch top diameter.

[3] International 1/4-inch rule, trees 6.6+ inches in d.b.h. to a 6-inch top diameter.

[4] Trees 5.6+ inches in d.b.h. to a 4-inch top diameter.

[5] Based on plots intact in 1968--plot 6 omitted.

Table 25—Volume per hectare at age 104 in 1955

Plot[1]	Western hemlock	Sitka spruce	Douglas-fir	All species
		Cubic meters[2]		
1	1619	34	16	1666
3	575	1152	0	1727
4	334	1519	36	1889
5	217	1704	17	1939
6	1229	434	8	1671
7	1242	527	40	1809
8	1653	41	0	1693
10	520	1236	0	1756
12	1129	434	0	1563
13	1176	250	0	1426
Mean[3]	940	766	12	1719

[1] Plots 2, 9, and 11 are not included; plot 2 was destroyed soon after establishment, plot 9 was accidentally destroyed by logging, and plot 11 contained substantial amounts of young Douglas-fir and red alder.

[2] Trees 14+ centimeters in d.b.h. to a 10.2-centimeter top diameter.

[3] Based on plots intact in 1968--plot 6 omitted.

Table 26—Volume per acre at age 116 in 1968

Plot[1]	Western hemlock			Sitka spruce			Douglas-fir			All species		
	Board feet [2]	Board feet [3]	Cubic feet [4]	Board feet [2]	Board feet [3]	Cubic feet [4]	Board feet [2]	Board feet [3]	Cubic feet [4]	Board feet [2]	Board feet [3]	Cubic feet [4]
1	139,931	159,046	23,628	3,097	3,393	496	1,620	1,739	249	114,649	164,178	24,373
3	51,892	57,991	8,558	120,476	126,421	18,161	0	0	0	172,368	184,412	26,719
4	28,369	33,550	5,113	157,972	168,656	24,313	2,800	3,136	459	189,141	205,342	29,885
5	19,484	22,360	3,349	170,615	178,909	25,740	1,766	1,883	269	191,865	203,151	29,359
7	105,459	120,793	18,091	54,556	58,280	8,418	4,042	4,538	670	164,057	183,611	27,179
8	141,699	166,575	25,261	4,260	4,585	661	0	0	0	145,959	171,161	25,922
10	40,473	46,461	6,965	135,537	138,464	19,884	0	0	0	176,010	184,924	26,849
12	105,251	119,287	17,676	45,579	47,679	6,838	0	0	0	150,829	166,966	24,514
13	102,842	117,008	17,436	28,673	29,857	4,285	0	0	0	131,515	146,864	21,721
Mean[5]	81,711	93,675	14,009	80,085	84,027	12,088	1,136	1,255	183	162,933	178,957	26,280

[1] Plots 2, 6, 9, and 11 are not included.

[2] Scribner rule, trees 11.6+ inches in d.b.h. to a 6-inch top diameter.

[3] International 1/4-inch rule, trees 6.6+ inches in d.b.h. to a 6-inch top diameter.

[4] Trees 5.6+ inches in d.b.h. to a 4-inch top diameter.

[5] Based on plots intact in 1968.

Table 27—Volume per hectare at age 116 in 1968

Plot[1]	Western hemlock	Sitka spruce	Douglas-fir	All species
		Cubic meters [2]		
1	1653	35	17	1705
3	599	1271	0	1870
4	358	1701	32	2091
5	234	1801	19	2054
7	1266	589	47	1902
8	1768	46	0	1814
10	487	1391	0	1879
12	1237	478	0	1715
13	1220	300	0	1520
Mean[3]	980	846	13	1839

[1] Plots 2, 6, 9, and 11 are not included; plot 2 was destroyed soon after establishment, plot 6 was destroyed by the 1962 Columbus Day storm (before remeasurement), plot 9 was accidentally destroyed by logging, and plot 11 contained substantial amounts of young Douglas-fir and red alder.

[2] Trees 14+ centimeters in d.b.h. to a 10.2-centimeter top diameter.

[3] Based on plots intact in 1968.

Table 28—Summary of stand characteristics of all plots, per acre basis, 1935-68

Species	Year	Age	Basal area	Average d.b.h. 1/	Number of trees	Volume		
		Years	Square feet	Inches		Board feet 2/	Board feet 3/	Cubic feet 4/
All	1935	83	417	18.7	218	121,684	138,522	20,932
species	1940	89	431	19.4	211	130,577	147,343	22,112
	1945	94	442	20.0	203	137,976	154,654	23,093
	1955	104	455	21.2	185	149,522	165,867	24,561
	1968	116	468	22.8	166	162,933	178,957	26,280
Western	1935	83	237	16.2	165	62,891	75,966	11,778
hemlock	1940	89	244	16.8	159	67,730	80,702	12,402
	1945	94	249	17.3	153	71,489	84,361	12,881
	1955	104	251	18.2	139	76,414	88,922	13,441
	1968	116	252	19.4	123	81,711	93,675	14,009
Sitka	1935	83	176	25.1	51	57,541	61,149	8,945
spruce	1940	89	183	26.0	50	61,525	65,154	9,489
	1945	94	190	26.7	49	65,360	69,033	10,026
	1955	104	200	28.4	45	72,035	75,760	10,947
	1968	116	212	30.6	42	80,085	84,027	12,088
Douglas-	1935	83	4	20.3	2	1,252	1,408	209
fir	1940	89	4	20.5	2	1,321	1,487	220
	1945	94	4	21.1	1	1,126	1,260	186
	1955	104	3	21.9	1	1,073	1,184	173
	1968	116	3	23.2	1	1,136	1,255	183

1/Quadratic mean diameter.

2/Scribner rule, trees 11.6+ inches d.b.h. to a 6-inch top diameter.

3/International 1/4-inch rule, trees 6.6+ inches in d.b.h. to a 6-inch top diameter.

4/Trees 5.6+ inches in d.b.h. to a 4-inch top diameter.

Table 29—Summary of stand characteristics of all plots, per hectare basis, 1935-68

Species	Year	Age	Basal area	Average d.b.h. [1]	Number of trees	Volume [2]
		Years	Square meters	Centimeters		Cubic meters
All	1935	83	38.7	47.5	539	1465
species	1940	89	40.0	49.3	521	1548
	1945	94	41.1	50.8	502	1616
	1955	104	42.3	53.8	457	1719
	1968	116	43.5	57.9	410	1839
Western	1935	83	22.0	41.1	408	824
hemlock	1940	89	22.7	42.7	393	868
	1945	94	23.1	43.9	378	902
	1955	104	23.3	46.2	343	941
	1968	116	23.4	49.3	304	980
Sitka	1935	83	16.4	63.8	126	626
spruce	1940	89	17.0	66.0	124	664
	1945	94	17.7	67.8	121	702
	1955	104	18.6	72.1	111	766
	1968	116	19.7	77.7	104	846
Douglas-	1935	83	.37	51.6	5	15
fir	1940	89	.37	52.6	5	15
	1945	94	.37	53.6	2	13
	1955	104	.28	55.6	2	12
	1968	116	.28	58.9	2	13

[1] Quadratic mean diameter.

[2] Trees 14+ centimeters in d.b.h. to a 10-centimeter top diameter.

Table 30—Summary of gross rate of growth per acre, 1935-68

Volume by apeciea	Age (yeara)					Period			
	83	89	94	104	116	1935-40	1941-45	1946-55	1956-68
	MEAN ANNUAL INCREMENT[1]					PERIODIC ANNUAL INCREMENT[2]			
Western hemlock:									
Board feet (Scribner rule) to a 6-inch top	758	761	761	735	704	807	752	493	441
Board feet (International 1/4-inch rule) to a 6-inch top	915	907	897	855	808	789	732	456	396
Cubic feet to a 4-inch top	142	139	137	129	121	104	96	56	47
Sitka apruce:									
Board feet (Scribner rule) to a 6-inch top	693	691	695	693	690	664	767	668	671
Board feet (International 1/4-inch rule) to a 6-inch top	737	732	734	728	724	668	776	673	689
Cubic feet to a 4-inch top	108	107	107	105	104	91	107	92	95
Douglaa-fir:									
Board feet (Scribner rule) to a 6-inch top	15	15	12	10	10	12	−39	− 5	5
Board feet (International 1/4-inch rule) to a 6-inch top	17	17	13	11	11	13	−45	− 8	6
Cubic feet to a 4-inch top	3	2	2	2	2	2	− 7	1	1
All apeciea:									
Board feet (Scribner rule) to a 6-inch top	1,466	1,467	1,468	1,438	1,405	1,482	1,480	1,155	1,118
Board feet (International 1/4-inch rule) to a 6-inch top	1,669	1,656	1,645	1,595	1,543	1,470	1,462	1,121	1,091
Cubic feet to a 4-inch top	252	248	246	236	227	197	196	147	143

[1] $(\text{Total volume/acre at age}_i)/\text{age}_i$.

[2] $(\text{Total volume at age}_{i+1} - \text{total volume age}_i)/(\text{age}_{i+1} - \text{age}_i)$.

Table 31—Summary of gross rate of growth per hectare, 1935-68

Volume by apeciea	Age (yeara)					Period			
	83	89	94	104	116	1935-40	1941-45	1946-55	1956-68
	MEAN ANNUAL INCREMENT[1]					PERIODIC ANNUAL INCREMENT[2]			
Western hemlock:									
CV10.2[3]	9.9	9.7	9.6	9.0	8.4	7.3	6.7	3.9	3.3
Sitka apruce:									
CV10.2[3]	7.5	7.5	7.5	7.4	7.3	6.3	7.5	6.4	6.6
Douglaa-fir:									
CV10.2[3]	.2	.2	.1	.1	.1	.1	−.5	−.1	.1
All apeciea:									
CV10.2[3]	17.6	17.4	17.2	16.5	15.8	13.8	13.7	10.3	10.0

[1] $(\text{Totalvolume/hectare at age}_i)/\text{age}_i$.

[2] $(\text{Total volume at age}_{i+1} - \text{total volume age}_i)/(\text{age}_{i+1} - \text{age}_i)$.

[3] Cubic metera to a 10.2-centimeter top.

A study established in 83-year-old, even-aged stands of Sitka spruce (*Picea sitchensis* (Bong.) Carr.) and western hemlock (*Tsuga heterophylla* (Raf.) Sarg.) at Cascade Head Experimental Forest in the Siuslaw National Forest on the Oregon coast traces their development for 33 years. Statistical data collected from 12 permanent sample plots during four periods of growth illustrate the tremendous productive capacity of the Sitka spruce–western hemlock type.

Keywords: Increment (volume), stand volume, increment (basal area), increment (height), even-aged stands, Sitka spruce, *Picea sitchensis*, western hemlock, *Tsuga heterophylla*.